BBC YOUR GUIDE TO SUMMER'S BEST METEOR SHOWER

#171 AUGUST 2019

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

SPECIAL ISSUE

1969-2019

APOLLO 11

50TH ANNIVERSARY

- The moonlanding retold blow by blow
- Rod Pyle's amazing secrets of Apollo
- Dallas Campbell's conspiracy shut-down

RETURN TO THE MOON
The new era of crewed lunar exploration

HUMANS + ROBOTS
A fresh view on the space mission debate

UK METEOR TRACKING
Latest on the Great British fireball hunt

MORNING MERCURY
Wake up with the closest planet to the Sun

GET LOST IN LYRA
Tour the tiny constellation packed with deep-sky gems

CORGI®

APOLLO 11 50TH ANNIVERSARY

CS90647 Apollo Command Module
Scale FTB Length 70mm **£12.99**

Responsible for carrying all three astronauts and the Lunar Module into lunar orbit, the Apollo Command module played a vital role in the Apollo 11 landings. Having taken off from Kenedy Space Center, Florida, on July 16th, the module delivered it's passengers to their destination in just four days. On their return to Earth the three astronauts had to spend 21 days in quarantine to ensure they hadn't contracted a 'moon disease'.

CS90646 Apollo Lunar Module
Scale FTB Length 52mm **£12.99**

The Lunar Module landed on the Moon's surface on the 20th July 1969 and still holds the record for being the first and only crewed vehicle to land anywhere other than Earth. Amazingly, a humble biro pen came to the aid of Buzz Aldrin and Neil Armstrong when a circuit breaker was damaged by the team. By jamming a biro in the circuit breakers hole the module managed to complete the Lunar Ascent!

Never underestimate the humble Biro pen

To order call **01843 233 512**
(Telephone order lines are open 9am-5pm Monday to Thursday and 9am-3pm on Friday)

Alternatively go to **www.corgi.co.uk**
or visit your local Corgi stockist!

YouTube /officialcorgi @corgi /corgidiecast

"One small step for man, one giant leap for mankind", words spoken by Neil Armstrong, the first man to walk on the moon. Those moments of the 21st July 1969 will resonate, entertain and inspire generations to come.

2019 celebrates the 50th anniversary of the Apollo 11 landings, the mission that was responsible for the first foot prints on the moon, which still remain there to this day. Corgi are proud to reintroduce two Apollo 11 die-cast models to the range in celebration of the anniversary this scientific feat.

Welcome

Join our 50th anniversary celebration of the Moon landing

This month is our second issue commemorating the 50th anniversary of Apollo 11's Moon landing, an occasion so big we had to mark it twice! By some happy providence, at the exact moment Neil Armstrong stepped on the lunar surface – 02:56 UT on 21 July – the site of this historic achievement will be almost perfectly placed for observing: the Moon nearing its highest point due south in the sky and the phase placed nicely to bathe the southwestern region of the Mare Tranquillitatis in dramatic shadows. Turn to page 52 of the Sky Guide for more detail on observing the area around Tranquillity Base, and more amazing highlights to see in his month's night sky.

There's much more about Armstrong and Aldrin's mission both before and after that first step on page 30, where news editor Elizabeth Pearson looks in detail at Apollo 11's mission plan. Then, on page 36 engineer and scientist Niamh Shaw looks ahead to plans for the next Moon landing. It's striking that this time the journey isn't a two-horse race; the US and Russia are key players, but now private enterprise, India, China and Europe are all developing plans either individually or as consortia. We are on the verge of a new era of lunar exploration.

While the technology to land on the Moon has been improving for the past five decades, the conspiracy theories remain, kept in a zombie state by 21st-century digital media. On page 65 Dallas Campbell shows how the persistent offenders crumble in the face of the physical facts.

I should also mention space historian Rod Pyle's feature on page 60, where he looks at a few of the Apollo programme's hidden aspects, which were essential to the achievements we salute this month.

Chris Bramley, Editor

PS Our next issue goes on sale Thursday 15 August.

HOW TO CONTACT US

Subscriptions, binders and back issues
03330 162119*
Mon–Fri 8am–6pm; Sat 9am–1pm

*Calls from landlines will cost up to 9p per minute. Call charges from mobile phones will cost between 3p and 55p per minute but are included in free call packages. If calling from overseas, please dial +44 (0)1604 973727

Editorial enquiries
+44 (0)117 300 8754
9.30am–5.30pm, Mon–Fri

Advertising enquiries
+44 (0)117 300 8276

Print subscription enquiries
bbcskyatnight@buysubscriptions.com

Digital subscription enquiries
bbcskyatnightdigital@buysubscriptions.com

Editorial enquiries
contactus@skyatnightmagazine.com

Subscription enquiries
UK enquiries: FREEPOST IMMEDIATE MEDIA (please write in capitals)
Overseas enquiries: PO Box 3320, 3 Queensbridge, Northampton NN4 7BF, UK

Editorial enquiries
BBC Sky at Night Magazine, Immediate Media Co Bristol Ltd, Eagle House, Colston Avenue, Bristol BS1 4ST

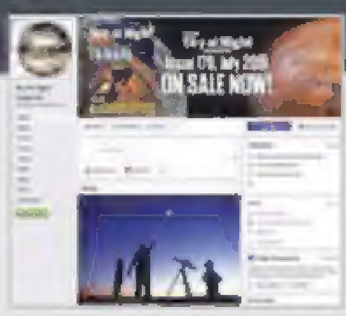
Become an Insider

The more we know about what you like, the better placed we are to bring you the best magazine possible. So we'd like to invite you to join our online reader panel 'Insiders'. Just log on to **www.immediateinsiders.com/register** to fill out the short registration survey and we'll be in touch from time to time to ask for your opinions on the magazine and other relevant issues.

Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team will be exploring in this month's episode on page 19

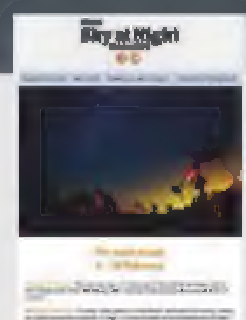
Online
Visit our website for competitions, astrophoto galleries, observing guides and more



Social Media
All the details of our latest issue on Twitter and Facebook, plus website and news updates

Podcasts
Listen to our Radio Astronomy podcasts where the magazine team and guests discuss astro news

iPhone/iPad
Get each month's issue on your iPad or iPhone, now with bonus image galleries



eNewsletter
The best targets to observe each week, delivered to your inbox. Visit our website to sign up

Find out more at: www.skyatnightmagazine.com

CONTENTS

Ⓒ = on the cover

Features

30 Apollo 11 – a giant leap
Ⓒ The extraordinary story of how we first walked on the Moon

36 Return to the Moon
Ⓒ A new space race is about to begin, with new players on board

60 Secrets of Apollo
Ⓒ Uncover Apollo's unsung items that helped us land on the Moon

65 How to crush the Moon landing conspiracies Ⓒ
We give you the rebuttals to silence the Apollo naysayers

68 The Great British fireball hunt Ⓒ
How a dedicated network of UK cameras is tracking meteorites

Regulars

6 Eye on the sky
10 Bulletin
16 Cutting edge Ⓒ
18 Inside *The Sky at Night*
20 Interactive
25 What's on
27 Field of view
28 Subscribe to *BBC Sky at Night Magazine*
72 Explainer
74 DIY Astronomy
98 Q&A: the Lunar Geologist

Astrophotography

76 Capture
78 Processing
80 Gallery

Reviews

86 William Optics Zenithstar 126 apo refractor
90 CEM40 centre-balancing equatorial mount
94 Books
96 Gear

16-PAGE CENTRE PULLOUT

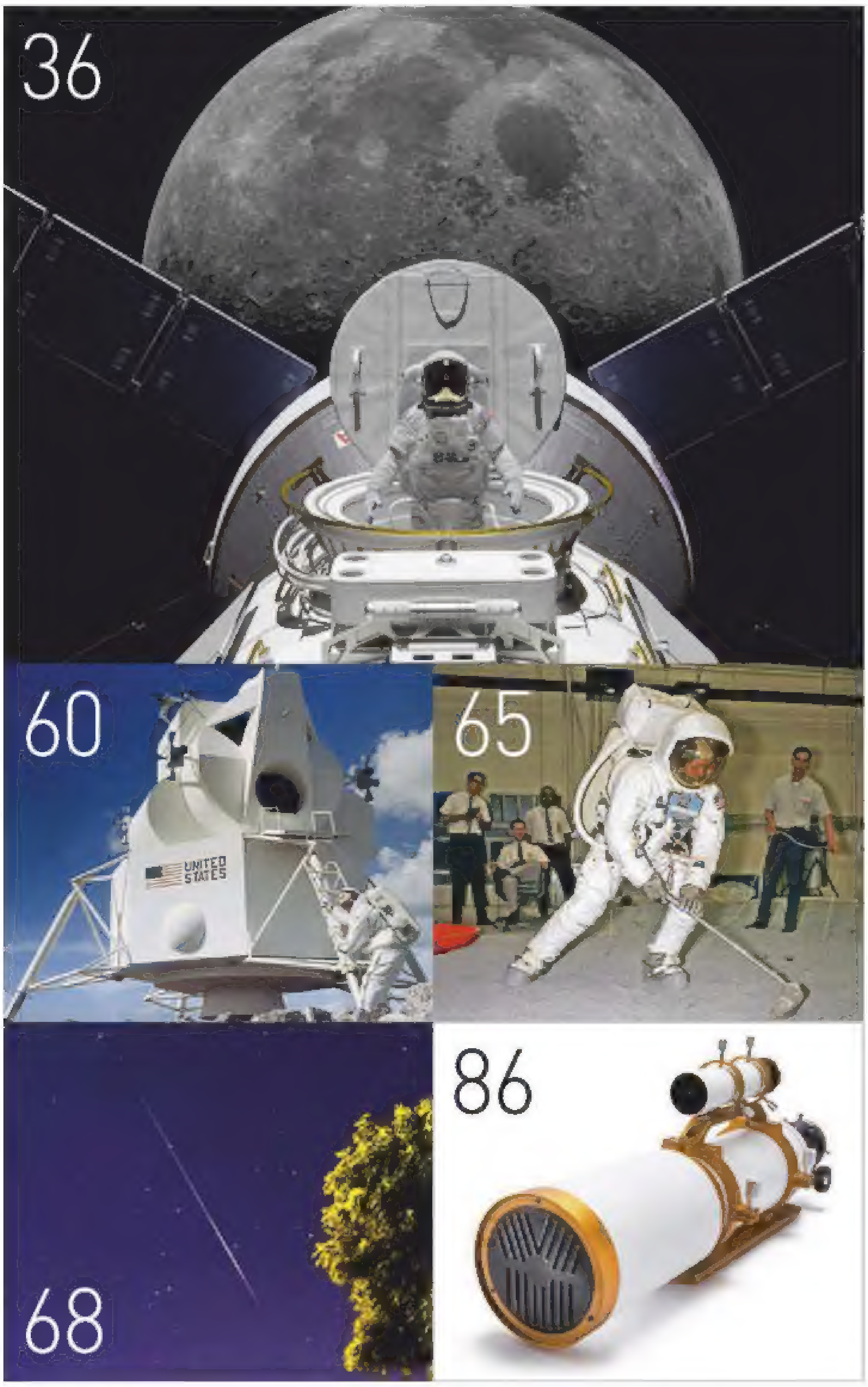
The Sky Guide

44 Highlights
46 The big three Ⓒ
48 The planets Ⓒ
50 August's all-sky chart
52 Moonwatch
53 Comets and asteroids
53 Star of the month
54 Binocular tour
55 The Sky Guide challenge
56 Deep-sky tour Ⓒ
58 August at a glance

COVER MAIN IMAGE: NASA, THIS PAGE: NASA X 3, MICHIKO SMITH/ALAMY STOCK PHOTO, WALTER MYERS/SCIENCE PHOTO LIBRARY, WWW.SECRETSTUDIO.NET, BBC

New to astronomy?

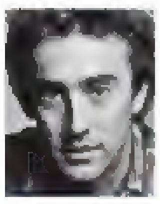
To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Dallas Campbell

Science presenter



Was Apollo 11 a hoax filmed in a studio? Dallas counters this and other Moon landing conspiracies. See page 65

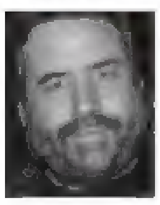
Elizabeth Pearson

News editor

50 years on, Elizabeth retraces the legendary footsteps of the Apollo 11 mission. See page 30

Rod Pyle

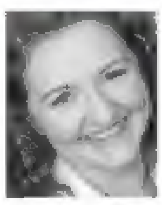
Space historian & author



From spacesuits to the computer system, Rod explores the unsung aspects of Apollo. See page 60

Niamh Shaw

Engineering & science writer



As a new race to the Moon gets underway, Niamh catches up with the many players. Turn to page 37

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/347aglx/** to access this month's selection of Bonus Content.

August highlights

Interview: Wally Funk

In 1962, US aviator Wally Funk was one of the Mercury 13, a group of women who for the first time were put through the same training regime as male astronauts. We sat down with Funk to discuss her extraordinary life and her ongoing race for space.

The Sky at Night: Return to the Moon

In the first of a two-part Apollo 11 special, *The Sky at Night* looks at the missions hoping to return to the lunar surface.

Audiobook previews: The race to the Moon

This month, audiobook excerpts explore the legacy of Apollo and what it took to put feet on the lunar surface.

Hotshots gallery, extra EQMOD files, binocular tour, observing forms, deep-sky tour chart, desktop wallpapers...**and much more**

PLUS: Every month

Night-sky highlights

Pete Lawrence and Paul Abel discuss the top sights to see this month.

EYE ON THE SKY

Sculpted by stars

A dynamic interstellar scene that has been moulded by the births and deaths of its resident stars

NASA SPITZER SPACE TELESCOPE, INFRARED ARRAY CAMERA (IRAC) AND THE MULTIBAND IMAGING PHOTOMETER (MIPS), 30 MAY 2019

The large Cave Nebula filling this image would have once been part of a much larger gas and dust cloud which has since been carved up by the radiation from stars. The bright red beacon at the tip of the nebula (pictured, centre top) is due to extensive heating of the dust by young stars. On its right is Cepheus B, a star cluster around 4-5 million years old, lying a few thousand lightyears away from our Sun.

In the lower right portion of the image, the multi-coloured patch is a breakaway nebula containing an unusual object. A small, blue "runaway" star located above the young nebula is hurtling through space. It's travelling so fast that it has created a cosmic bow shock in front of itself, seen as a red arc in the image (centre, right).

Using data from two instruments on NASA's Spitzer Space Telescope, the Infrared Array Camera (IRAC) and the Multiband Imaging Photometer (MIPS), greater detail was captured than can be observed in a previously released image of the area containing data from the IRAC alone.

NASA/JPL-CALTECH

△ Big heart

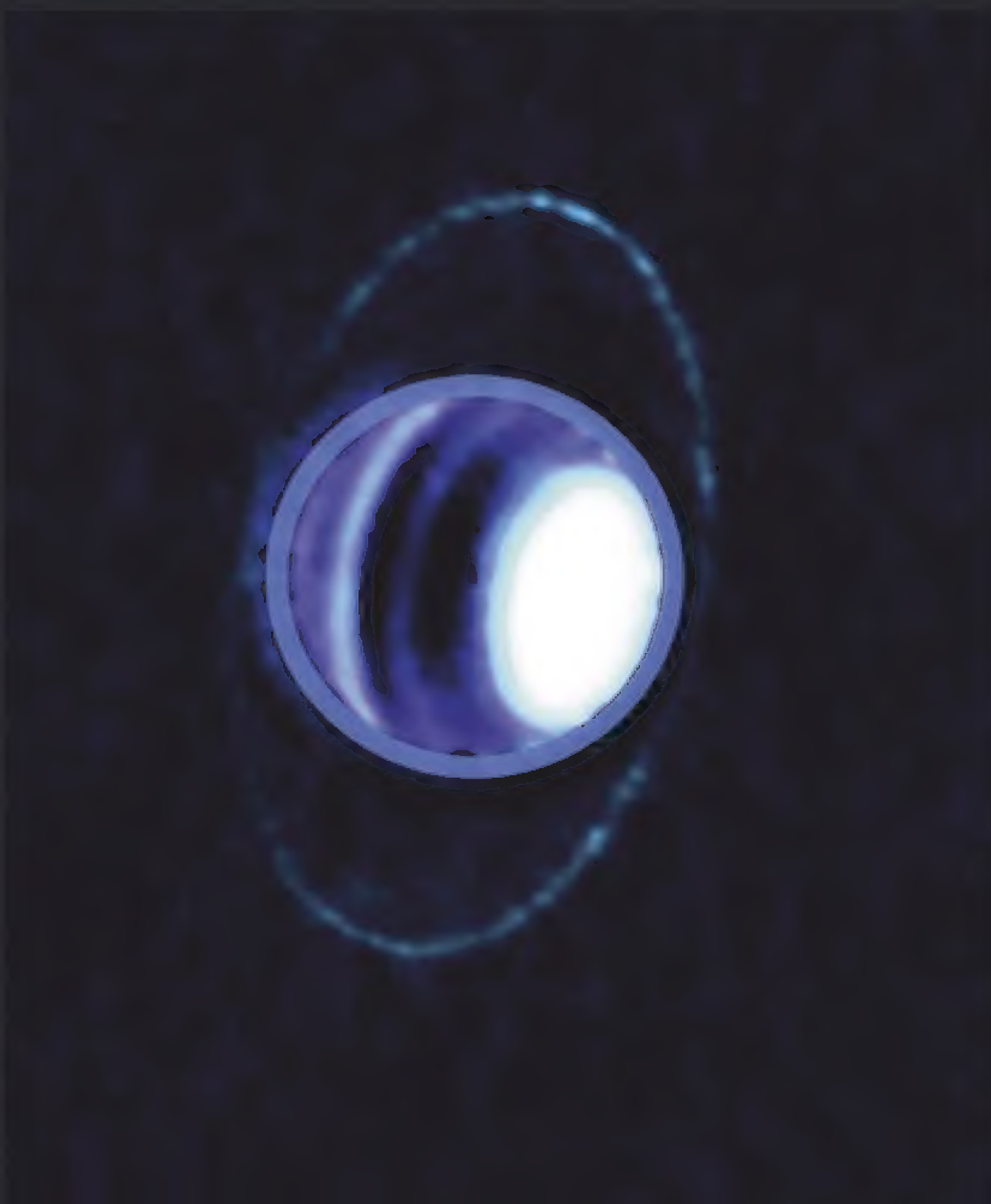
HUBBLE SPACE TELESCOPE, 13 JUNE 2019

Galaxy ESO 495-21 may be relatively small, at only 3,000 lightyears across (the Milky Way is 100,000 lightyears across), but it is certainly full of activity, with a large stellar nursery at its heart. There are also indicators that there is a supermassive black hole at its centre, which is rare for a galaxy of this size.

Icy glow ▷

ATACAMA LARGE MILLIMETER/ SUBMILLIMETER ARRAY, VERY LARGE TELESCOPE, 20 JUNE 2019

The rings of Uranus are invisible to all but the largest of telescopes, but when thermally imaged their frosty blue glow shines brightly. This image was produced as part of a study of the thermal emissions from the rings of Uranus, which has determined their temperature for the first time, a frigid –196.15°C. Other details are also revealed using this imaging technique: an example of these are the dark bands across the atmosphere, which are comprised mostly of hydrogen sulphide gas.

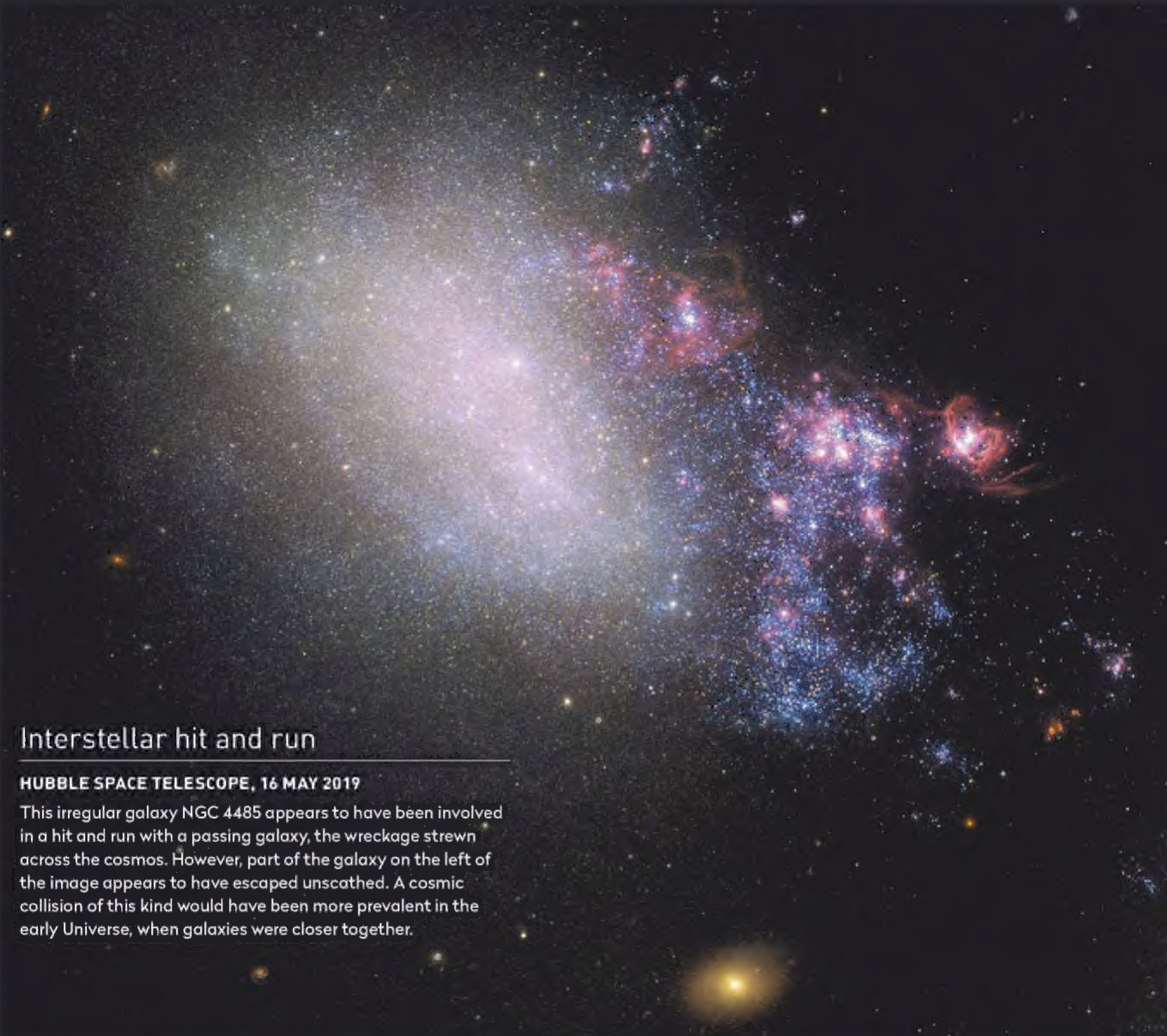


NASA, ALMA (ESO/NAOJ/NRAO) EDWARD M. MOLTER AND IMKE DE PATER), ESO/A. CLAEYSSENS, NASA AND ESA

◁ Happy hydrogen halo

VERY LARGE TELESCOPE, 24 JUNE 2019

The red halo of hydrogen gas seen here is the product of a cosmic optical illusion. The hydrogen gas actually surrounds a distant galaxy, which is magnified into view via the gravitational lensing effect of the closer central galaxy cluster in this image. The warping of spacetime around the massive galaxy cluster causes the bending of light, making the hydrogen gas appear as a halo.



Interstellar hit and run

HUBBLE SPACE TELESCOPE, 16 MAY 2019

This irregular galaxy NGC 4485 appears to have been involved in a hit and run with a passing galaxy, the wreckage strewn across the cosmos. However, part of the galaxy on the left of the image appears to have escaped unscathed. A cosmic collision of this kind would have been more prevalent in the early Universe, when galaxies were closer together.

The latest astronomy and space news, written by Elizabeth Pearson

BULLETIN


An artist's impression of the merging galaxies B14-65666 and (inset) a composite Hubble Space Telescope Image

Earliest galaxy crash ever seen

Merging galaxies give an insight into the early life of the Universe

Two galaxies have been spotted crashing and merging together just one billion years after the Big Bang, the earliest such collision that has so far been observed.

In a recent set of observations a team of astronomers led by Takuya Hashimoto from Waseda University in Japan looked at galaxy B14-65666 (B14). Its light has taken 13 billion years to get to us, meaning we see it as it was in the earliest stages of the Universe. By looking at the oxygen, carbon and dust within the galaxy using the Atacama Large Millimeter/Submillimeter Array (ALMA) and the Hubble Space Telescope, the team were able to unpick detail around the galaxy's structure. They saw that although the galaxy acts as a single system, it has two separate 'blobs' moving at different speeds – a tell-tale signature that two galaxies have merged to form it.

Another sign that B14 is the product of a merger is its incredible rate of star birth. When galaxies collide, the mixing of gas creates a huge burst of star formation, and B14 is creating stars at 100 times the rate of the Milky Way, despite having only 10 per cent of its mass.

Due to its small size and youthful age, it's thought that our view of the galaxy shows it in the earliest stages of its evolution. As mergers are a critical part of galactic growth, astronomers are excited to have the opportunity to study such a system in its infancy.

www.almaobservatory.org

Comment

by Chris Lintott

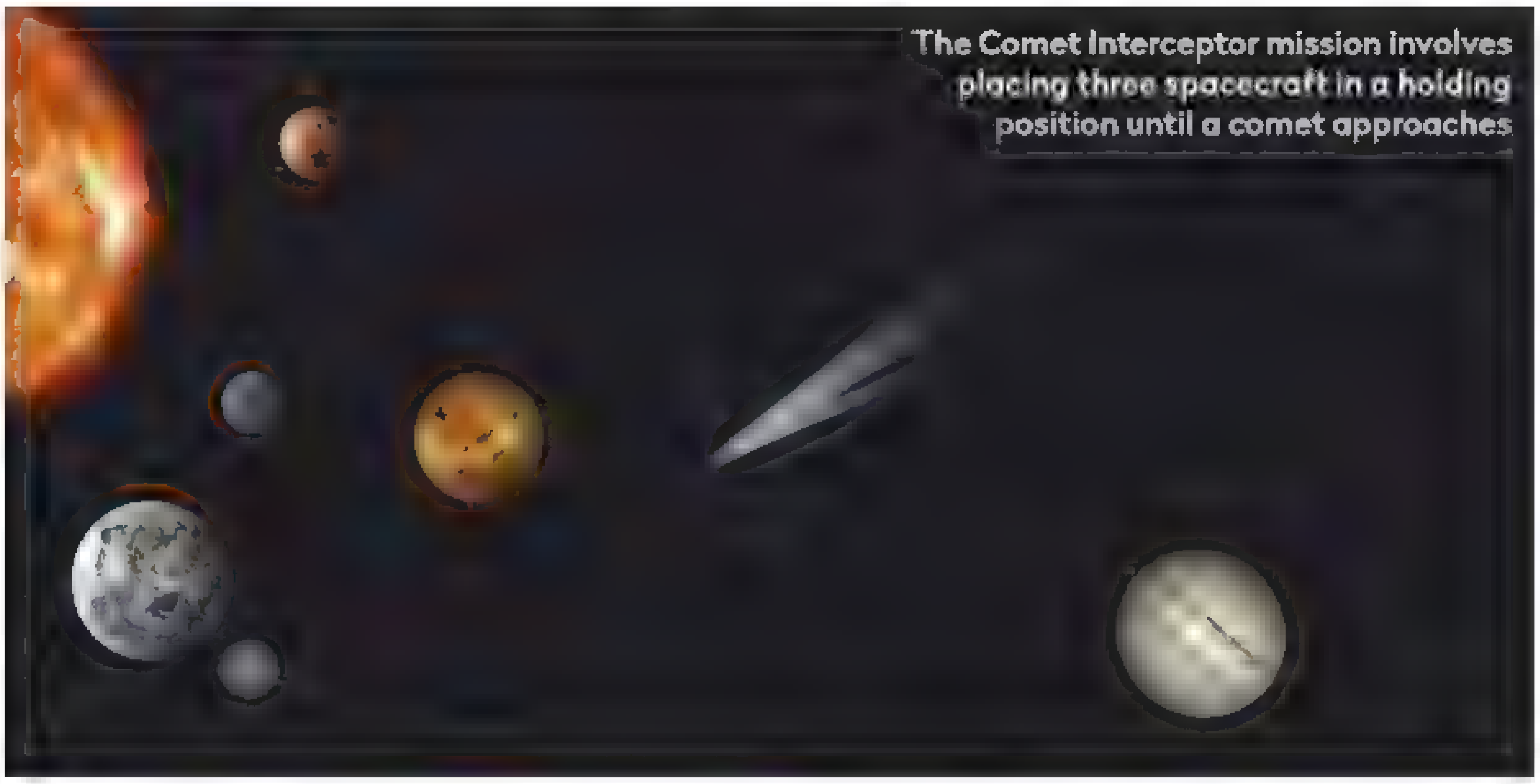
If our understanding of how galaxies grow and form is right, every system we see in the local Universe went through the kind of event that we see here many times. Our Milky Way will have been the product of tens of mergers, or more.

The large galaxies that we see today can't form directly. What's known as the hierarchical picture suggests that tiny protogalaxies – smaller even than the puny systems caught in a merger – form very early on. From there, the two are drawn together by their own gravity, resulting in a series of mergers, building up larger systems.

This process has been hard to see in the real Universe, but with this observation we can start to understand this hidden chapter of the past.

Chris Lintott co-presents *The Sky at Night*

NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN, ALMA (ESO/NAOJ/NRAO) NASA/ESA HUBBLE SPACE TELESCOPE/HASHIMOTO ET AL ESA, SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, NASA/JPL/UNIVERSITY OF ARIZONA



The Comet Interceptor mission involves placing three spacecraft in a holding position until a comet approaches

UK to lead comet hunting mission

Three spacecraft will investigate an outer Solar System visitor

UK scientists will head up ESA's latest mission, Comet Interceptor, which will track down a long-period comet. These bodies come from the distant Oort cloud and are the pristine material left over from the birth of the Solar System.

International teams led by University College London and the University of Edinburgh will build three spacecraft, which are expected to launch in 2028 before waiting in solar orbit for a suitable target to come by.

"In 1986 the UK-led mission to Halley's Comet became the first to observe a cometary nucleus and, more recently, UK scientists took part in another iconic European comet mission, Rosetta. Now our scientists will build on that impressive legacy by attempting to visit a pristine comet for the very first time and learn more about the origins of our Solar System," says Chris Lee from the UK Space Agency.
www.gov.uk

NASA mission is heading to Titan's skies

On Titan, Dragonfly will cover twice the distance of all Mars rovers combined

NASA's latest planetary mission, Dragonfly, will return to Saturn's icy moon, Titan.

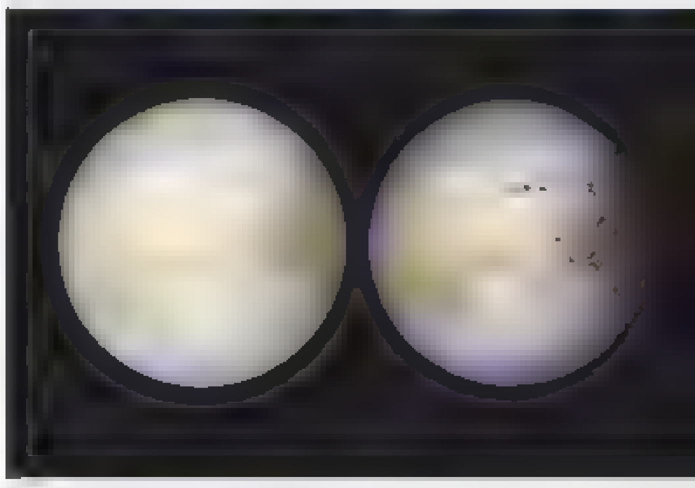
The mission will send a rotocopter – an eight-motored, drone-like spacecraft – to fly through Titan's thick atmosphere. The moon is rich in organic chemicals, which are the building blocks of all known biology, and could give insight into how life arose on Earth.

NASA's previous Saturn mission, Cassini, revealed that Titan has many diverse environments – from dunes made of organic 'sand' to rivers of methane. While the previous landing mission to the moon, ESA's Huygens probe, stayed put in one location, Dragonfly would be able to leapfrog up to 8km between these strange landscapes.

"Visting this mysterious ocean world could revolutionise what we know about life in the Universe. This cutting-edge mission would have been unthinkable even just a few years ago, but we're now ready for Dragonfly's amazing flight," says NASA administrator Jim Bridenstine.

Dragonfly is due to launch in 2026 and reach Titan in 2034. The intial mission will be over two and a half years, aiming to cover 175km of terrain.
www.nasa.gov

NEWS IN BRIEF



Jupiter's salty moon

The Hubble Space Telescope has revealed that yellow patches on the surface of Europa are sodium chloride, the same chemical that makes up table salt. This could mean the ocean believed to lie under Europa's icy crust is salty, like Earth's. The compound may be a sign that the ocean floor has hydrothermal vents, which are havens for life on Earth.

Brown dwarfs are stars

Brown dwarfs form like stars and not giant planets according to a survey by the Gemini Observatory. Astronomers found that because planets form by accumulating material, lightweight giant planets were more common than heavy ones. The opposite is true for brown dwarfs, suggesting they form from a cloud of collapsing gas.

Just like Jupiter

Jupiter-like exoplanets tend to be found in Jupiter-like orbits, a new survey has revealed. Observations by the Gemini Planet Imager found that most gas-giant exoplanets tend to be found between 3 to 10 AU (1 AU is the distance between the Sun and Earth). Jupiter lies in the middle at 5.2 AU.

Sun's history uncovered in Apollo rocks

New research will uncover the extent to which solar activity shaped planetary conditions

Moon rocks collected by the Apollo missions, and perhaps those collected by future lunar missions, could help investigate another of our Solar System's key bodies – the Sun. A record of solar radiation could be locked away inside Moon rocks, giving scientists a glimpse into how the Sun has changed over time and its effect on the habitability of the inner planets.

The young Sun was much more volatile than it is today, but the question is: exactly how volatile?

"We didn't know what the Sun looked like in its first billion years," says Prabal Saxena from NASA's Goddard Space Flight Center, who led the study. "It probably changed how quickly Mars lost its atmosphere, and it changed the atmospheric chemistry of Earth."

Saxena's team measured levels of sodium and potassium in Moon rocks collected on the Apollo missions. Theories suggest both Earth and the Moon should be made of the same stuff, but these two elements are much rarer on the Moon than our own planet. On the Moon, the solar radiation has stripped them away, as it has no atmosphere to offer protection.

Along with the Moon rocks, the team also analysed these chemical levels in lunar meteorites, to determine how active the infant Sun was.

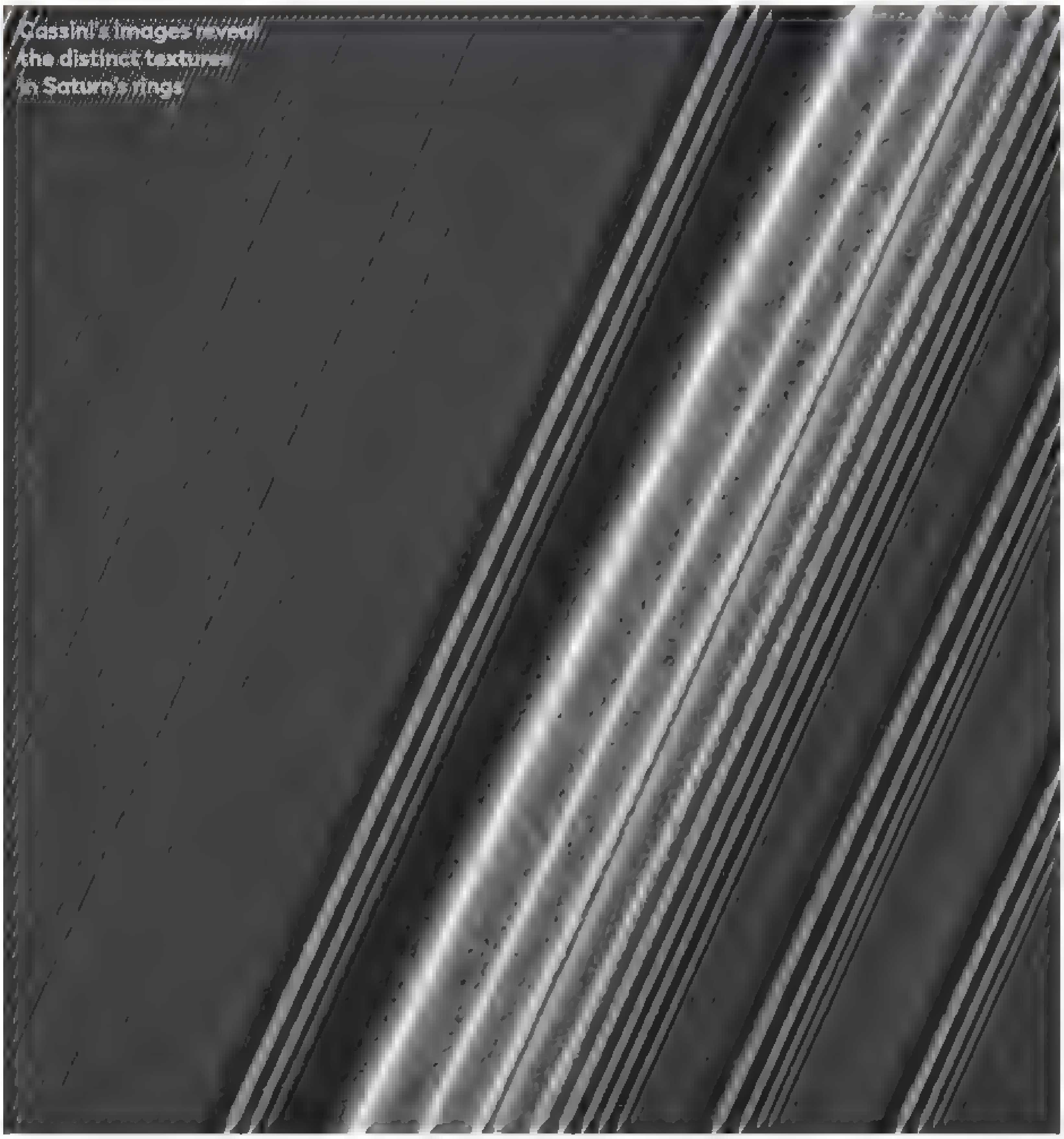
As the activity of a star can affect a planet's atmosphere – and therefore its habitability – the team wanted to make a comparison to other young stars. While making this comparison directly is difficult, activity is linked to a star's rotation rate, which is much easier to observe. The team found the infant Sun rotated once every nine or 10 days, slower than at least half of today's young stars (today the Sun takes 24 days to rotate). However, this was still active enough to produce flares 10 times larger than the biggest in recorded history up to 10 times a day.

With no atmosphere to soak up the rays, the Moon has always been a great spot to study solar radiation – five of the Apollo missions deployed an experiment to capture solar-wind particles. As more lunar missions are planned in the coming decade, the team hopes to learn more about not just the lunar surface, but the entire Solar System.
https://www.nasa.gov/goddard

Clues to how the Sun has evolved (left) are being unlocked by Apollo's legacy. The Moon's lack of atmosphere is ideal for catching solar wind (above)

NASA/GSFC/SOLAR DYNAMICS OBSERVATORY, NASA/ IMAGE SCANNED BY KIPP TEAGUE, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE X 2

A mosaic of Cassini images shows Daphnis, one of Saturn's ring-embedded moons, creating waves in the Keeler gap



Cassini's images reveal the distinct textures in Saturn's rings

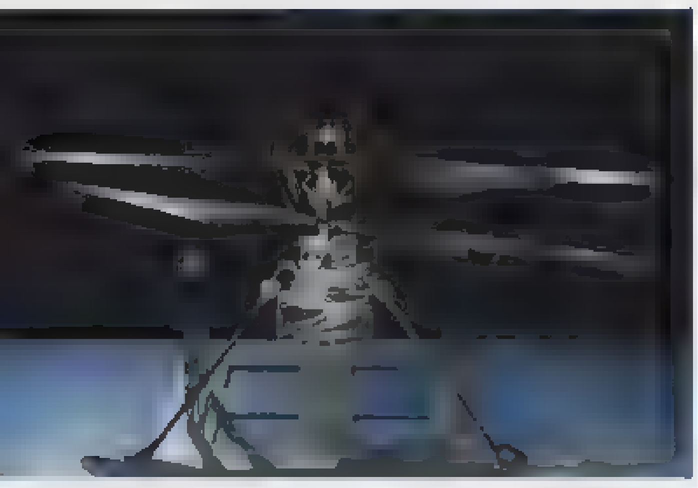
New details in Saturn's rings revealed

In 2017, at the end of its 13-year mission around Saturn the Cassini spacecraft dived between the planet and its rings. Now, a new paper reveals the results from that dive showing Saturn's rings in astonishing detail and uncovers how the gas giant's many moons helped to shape them.

"These new details of how the moons are sculpting the rings provide a window into Solar System formation, where you also have disks evolving under the influence of masses embedded within them," says Cassini research scientist Matt Tiscareno of the SETI Institute who led the study.

The new results also uncover new mysteries. For instance, the rings have three distinct textures – clumpy, smooth and streaky – separated into distinct bands, but the reason why is still unknown.

NEWS IN BRIEF



Mars helicopter ready

A prototype Martian helicopter is undergoing final tests before being launched alongside the Mars 2020 rover. The 1.8kg probe is designed to fly in Mars's atmosphere, which is only 1 per cent as dense as Earth's. If it's successful, then fleets of similar spacecraft could explore the Martian skies.

Galaxies re-classified

Citizen scientists from Galaxy Zoo have helped show there's no correlation between the size of a galaxy's bulge and how tightly its arms are wound. The finding, based on the careful cataloguing of the shape of 6,000 galaxies, overturns the Hubble method of classification, which was first created by Edwin Hubble in 1927.

Ancient Scottish impact

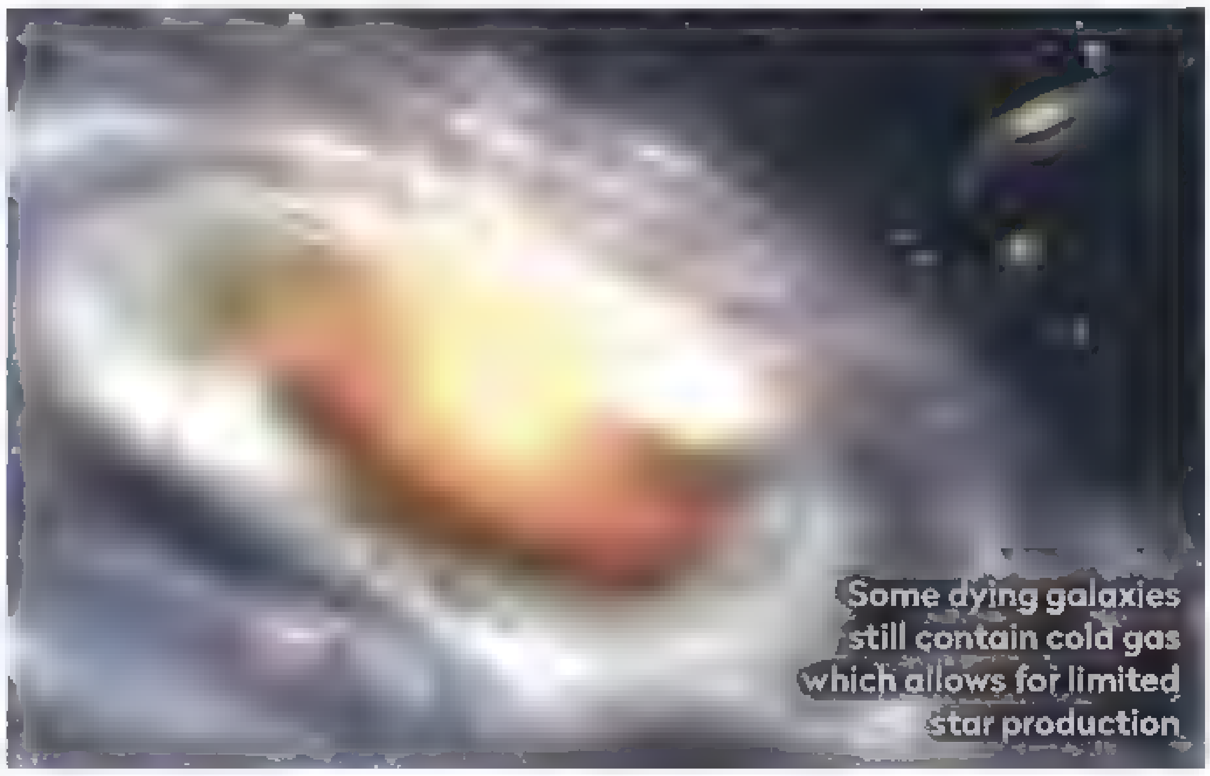
Evidence of a 1.2 billion-year-old meteor strike has been unearthed off the coast of Scotland. The meteor is thought to be 1km wide, making it the largest meteor impact known in the UK. "It would have been quite a spectacle when this large meteorite struck a barren landscape, spreading rock debris over a wide area," says study leader Ken Amor of the University of Oxford.

NASA/J.P. CALTECH X 2, MARS EXPLORATION ROVER MISSION/CORNEL/JPL/NASA, DANIEL KENEALY

BULLETIN

New phase of galactic life revealed

Some galaxies have one last gasp before retiring from forming



Some dying galaxies still contain cold gas which allows for limited star production

A recently discovered type of galaxy, a cold quasar, could be an entirely new phase of galactic evolution.

Quasars are galaxies with supermassive black holes at their centres, surrounded by a disc of hot gas with high-speed jets throwing material out into space. Over time, these jets choke off the gas from the main galaxy, stopping it from forming new stars – a process known as quenching.

However, a recent study using observations with the Sloan Digital Sky Survey (SDSS) found that 10 per cent of galaxies still had some cold gas within them even after they had entered this final stage in their lives.

"These galaxies are rare because they're in a transition phase – we've caught them right before star formation in the galaxy is quenched and this transition period should be very short," says Allison Kirkpatrick from the University of Kansas who led the study.

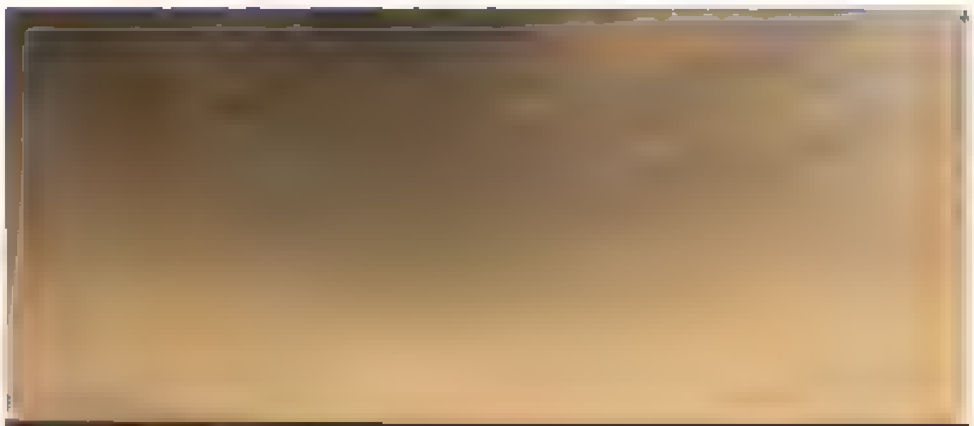
www.sdss.org

Do meteors make Mars cloudy?

The secret ingredient of Martian clouds could be meteorite dust, according to a new study. Though astronomers have seen clouds above Mars for decades, they've struggled to explain their presence.

Clouds only form when there is something for the atmospheric moisture to 'seed' onto, such as dust. However, astronomers have yet to find any potential seeds in the region of the Martian atmosphere where the clouds are found, 30km above the surface. The study suggests the dust from meteorites hitting the atmosphere could be providing the cloud seeds.

"We're used to thinking of Earth, Mars and other bodies as these really self-contained planets that determine their own climates," says Victoria Hartwick, from the University of Colorado, Boulder, who led the study. "But climate isn't independent of the surrounding Solar System."



Dead calm: dust from meteorites could be seeding Martian clouds

These clouds have a large impact on the current Martian climate, especially on high altitude temperatures.

"More and more climate models are finding that the ancient climate of Mars, when rivers were flowing across its surface and life might have originated, was warmed by high altitude clouds," says Brian Toon from the University of Colorado, Boulder.

www.colorado.edu

Rise and shine: noctilucent clouds, which appear high in Earth's atmosphere, can be spotted between 90–120 minutes after sunset

Bumper year for noctilucent clouds

The year 2019 has been excellent for spotting noctilucent clouds (NLCs). The elusive clouds are normally only seen between 70 to 50° of latitude, but in June they were seen as far south as Albuquerque, New Mexico.

The subtle clouds are the highest found in Earth's atmosphere, occurring at an altitude between 70 to 90km in the mesosphere. They're only visible in the summer twilight, when the Sun is at the right angle below the local horizon to illuminate the high-altitude clouds, making them stand out against the background sky, which remains dark.

Sightings of NLCs have been creeping south for several years. It's thought that climate change, the changing solar cycle or a combination of both these factors is responsible for the shift in the displays.

Our experts examine the hottest new research

CUTTING EDGE

Dead or alive: the study of isotopes in an exoplanet's atmosphere gives clues about its habitability

Sniffing the oxygen on exoplanets

Oxygen in an exoplanet's atmosphere could mean life... or a boiling hellscape

One of the major drivers for exoplanetary research is trying to discover twins of our own homeworld. Earth-like planets orbiting within the 'habitable zone' of their sun's – where it's neither too hot nor too cold for oceans of liquid water – are thought to offer the best conditions for supporting life. The next step after discovering a possibly suitable world is to try to detect signs of life that are actually present on that remote planet, using no more than the light we can gather in our telescopes.

One promising potential 'biosignature' on a planetary scale is the presence of oxygen in the atmosphere. Oxygen is a very reactive gas and so a significant amount of it in a planet's atmosphere indicates some process that is releasing oxygen faster than it can react with the planet's crust – the only reason that you and I are currently enjoying deep lungfuls of oxygen-rich air is because life (specifically photosynthetic cells) has pumped it out.

Unfortunately for the search for life beyond Earth, biology isn't the only phenomenon that can produce an oxygen-rich atmosphere – it's not a unique signature of life. If a planet undergoes a runaway greenhouse effect, as has befallen Venus, any oceans it once had are boiled away and water vapour streams into the upper atmosphere. Here, the H_2O is split by ultraviolet radiation into hydrogen – which rapidly escapes into space as it is so light – and oxygen gas.

The next step after discovering a possibly suitable world is to try to detect signs of life on that remote planet

Searching for signs of life

So detecting an oxygen-rich atmosphere, frustratingly, could mean the terrestrial exoplanet is either a hellish Venus or an idyllic Earth. How could we tell them apart?

The key, says Andrew Lincowski and his colleagues at the NASA Virtual Planetary Laboratory, University of Washington, is to look at the isotopes present in the atmosphere. The two different atoms making up water, hydrogen and oxygen, exist in both lighter and heavier isotopes, meaning they have more or fewer neutrons in their nucleus. And if a planet has undergone a runaway greenhouse effect, the lighter isotopes more readily escape the atmosphere into outer space, leaving behind a greater proportion of heavy-hydrogen (deuterium) and heavy-oxygen (which has two extra neutrons). Proportionally, Venus has one hundred times more atmospheric deuterium than Earth.

These types of isotope measurements can be made on transiting exoplanets using the James Webb Space Telescope (JWST). Lincowski has calculated that if a terrestrial planet orbiting a late-stage M dwarf star lost its ocean in a manner similar to Venus, the tell-tale proportions of the remaining atmospheric isotopes will be detectable by JWST when it launches in 2021. These measurements could only need observations of the exoplanet transiting its M dwarf star a handful of times.

Perhaps the most enticing exoplanet system to attempt these isotope measurements on is TRAPPIST-1. This planetary system has seven known exoplanets – two of which, the d and e planets, orbit with the habitable zone. Do either of these worlds hold oxygen in their atmospheres? If so, is it due to a runaway greenhouse effect, or could they potentially harbour life? We may well know in just a few years.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Observing Isotopologue Bands in Terrestrial Exoplanet Atmospheres with the James Webb Space Telescope – Implications for Identifying Past Atmospheric and Ocean Loss* by Andrew P Lincowski, Jacob Lustig-Yaeger and Victoria S Meadows. **Read it online at https://arxiv.org/abs/1905.12821**

NASA/JPL-CALTECH, ICRAR

Black hole bullets

Judging black holes from the size of their jets could be misleading

Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

Black holes are supposed to be simple creatures. Though the detailed physics of what happens at their centres may never be understood, from the outside, beyond the event horizon they're just a sink, the Universe's perfect plugholes.

Yet things are never quite that easy. Material doesn't just fall into black holes directly, it builds up in accretion disks, heated by friction to enormous temperatures. If the black hole is spinning, it twists space along with it, dragging powerful magnetic fields around and twisting them up. This can send jets of material shooting out at high speed, away from the black hole – and this month's paper suggests that the behaviour of such jets may be even more complicated than previously thought.

If the black hole is spinning, it twists space along with it, dragging powerful magnetic fields around and twisting them up

In particular, it's becoming clear that such jets can have remarkably varied behaviour, sometimes changing from hour to hour or even minute to minute. Studying a system called V404 Cygni – a giant star in orbit around a black hole which weighs in at nine solar masses – a team of astronomers led by James Miller-Jones of the International Centre for Radio Astronomy Research at Curtin University in Perth report behaviour never before seen.

The curious case of V404 Cygni

V404 Cygni is a microquasar, a smaller version of the bright accretion disks we see around the supermassive black holes at the centre of galaxies. It has a history of sudden outbursts, having first been catalogued as a nova when it brightened in 1938, it most recently flared during 2015. This was the first outburst since the 1980s, and the world's telescopes were on the case. Even while observations were going on it was clear unusual things were taking place – though previous outbursts caused flickering seen in X-ray telescopes, this time activity was recorded in the optical too.

ALMA observes in what astronomers call the 'sub-mm', short wavelength radio with frequencies similar to those used in microwave ovens. At these wavelengths, the combined resolving power of the scope's many dishes allows the structure of the jets to be seen. For each observation the jets change, especially during an intense outburst on 22 June 2015.

During this phase, blobs of material could be seen travelling along the jet, racing along at a third of the speed of light. These cosmic bullets are being expelled, the authors argue, from the very inner regions of the accretion disk, making a last-minute escape from whatever fate awaits material that crosses the black hole's event horizon.

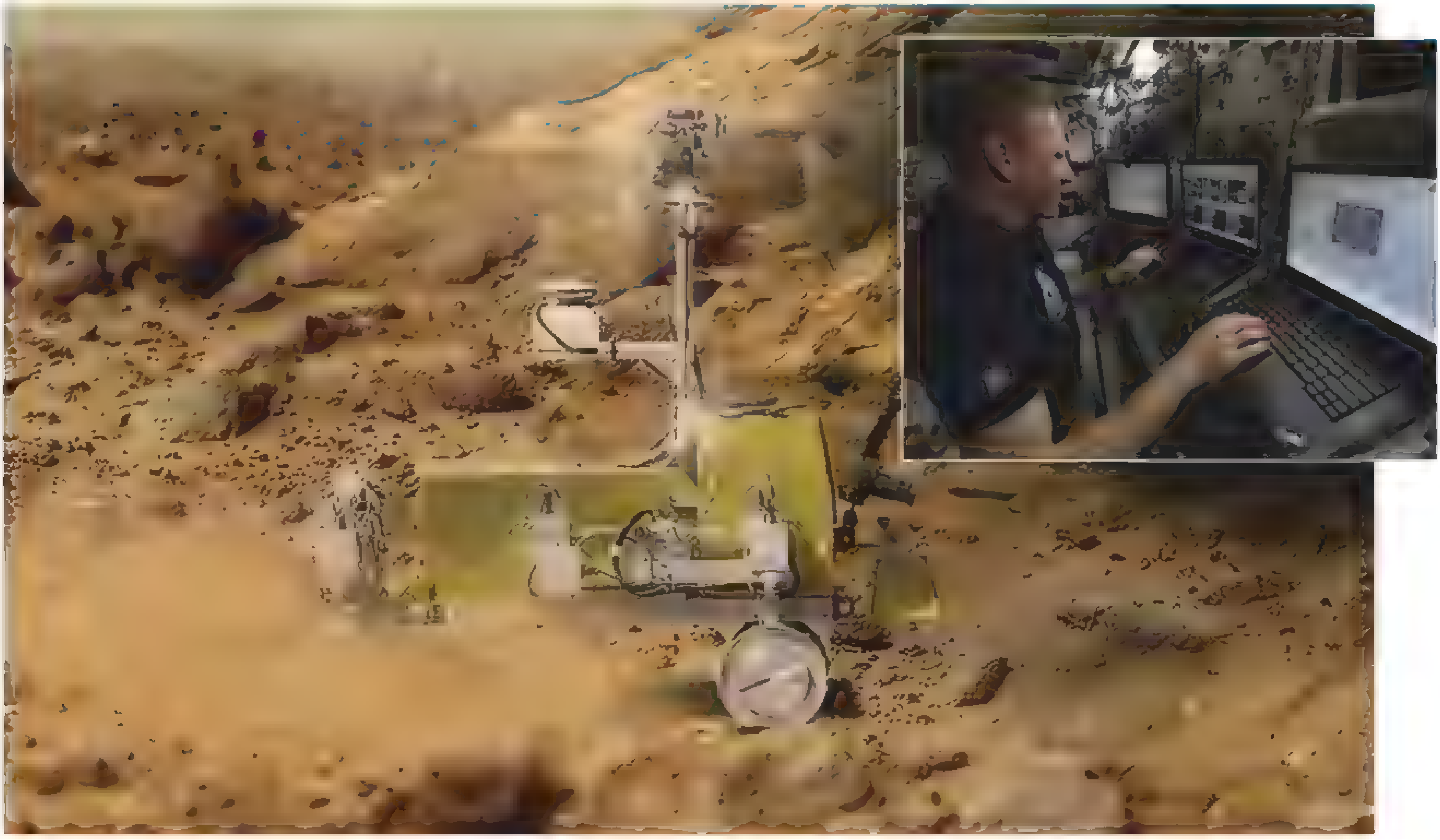
So what's going on? One possibility is that the black hole is wobbling on its axis as it spins, otherwise known as a rapid precession. It also seems likely that the material flowing from the large companion star onto the accretion disk is arriving out of alignment with the spin of the black hole. The physics of such a misaligned system allows for material to more easily be expelled, even while the black hole itself grows at a prodigious rate. Most importantly though, studying this local black hole do its thing warns us to be cautious when interpreting observations of more distant, and more massive systems; even these apparently simple objects can make things very complicated indeed.

An artist's impression of V404 Cygni shows it drawing in material from a nearby star (left). Jets of gas (right) are released from its disc

Chris Lintott was reading... *A rapidly-changing jet orientation in the stellar-mass black hole V404 Cygni* by James C A Miller-Jones et al.
Read it online at arxiv.org/abs/1906.05400

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



▲ **Taking control: in 2016 astronaut Tim Peake (inset) used rover controls on the International Space Station to guide a prototype rover across the Mars Yard at Airbus Defence and Space, Stevenage**

AIRBUS D&S, ESA/NASA, JOHN ZARNECKI, NASA, JIM MILLER/ISTOCK/GETTY IMAGES

In July's *Sky at Night*, the team spoke to **Prof John Zarnecki** about human and robotic space missions. He looks at why most deep space exploration since Apollo has involved unmanned missions

Back in July 1969 I was taking my first summer holiday as a fully fledged student and we were in Paris, camping in the Bois de Boulogne, en route south to the Sun. We headed into the city and my first view of the historic steps on the Moon was through a plate glass window in the Champs-Élysées. I could not then have imagined that I would meet the first two men to walk on the Moon.

The Apollo programme was a child of its time, driven by global geopolitical forces – but science was far from neglected. Apart from returning collected lunar samples, Apollo 11 performed in situ science measurements. Some, such as the Swiss-led Solar Wind Composition Experiment, were returned to Earth by the astronauts after exposure to the lunar environment, while others, such as the Lunar Seismic Experiment were left behind and the results telemetered back to Earth over an extended period.

Since those heady days our knowledge of the Solar System has been truly revolutionised, not by human exploration but by the increasingly sophisticated armada of robotic spacecraft, which have carried out at least a preliminary investigation of nearly all its elements. I have been fortunate enough to have played a part in some of these, being closely involved with the Giotto spacecraft, which flew a mere 596km from the nucleus of Halley's Comet. I spent nearly 20 years of my career as a principal investigator on the Huygens probe, part of the Cassini-Huygens mission to Saturn and Titan. And I was also fortunate to play a part in the comet chaser mission, Rosetta, and the nearly successful Beagle 2 mission to Mars.

The advantages of robotic missions over human-led missions are clear – we can now go anywhere in the Solar System with robots while humans, for the foreseeable future, will be confined only as far as Mars. While our scientific instruments are often delicate and need to be treated with care, they are

John Zarnecki is a professor at The Open University and chair of the UK Space Agency's Science Policy Advisory Committee

not nearly as delicate as humans. Our instruments don't need food and water, can usually survive long exposure to vacuum and moderate heat and cold. Many of them are also not too fussy when it comes to exposure to radiation.

But I don't subscribe to the humans vs robots debate – we need both, though often for different reasons. I believe that they can co-exist and benefit from each other in a synergistic way. Crewed missions have their advantages. And the human need to explore is a strong driver. In the UK, the success of the seventh UK astronaut, Tim Peake, and his mission shows public interest is still there.

There are probably some things that humans can do better, like dealing with the unexpected. Apollo 17 astronaut Harrison Schmitt famously noticed orange soil on the lunar surface and as a geologist realised its significance: a robot would probably have missed this.

As plans to return to the Moon appear to be crystallising and Mars is getting closer to being on our radar for human exploration, I'm hopeful that science will benefit. As scientists we have to remember that there are other perspectives, but as long as science is high on the agenda we should embrace the desire for human exploration and be happy to play our part.

Looking back: The Sky at Night

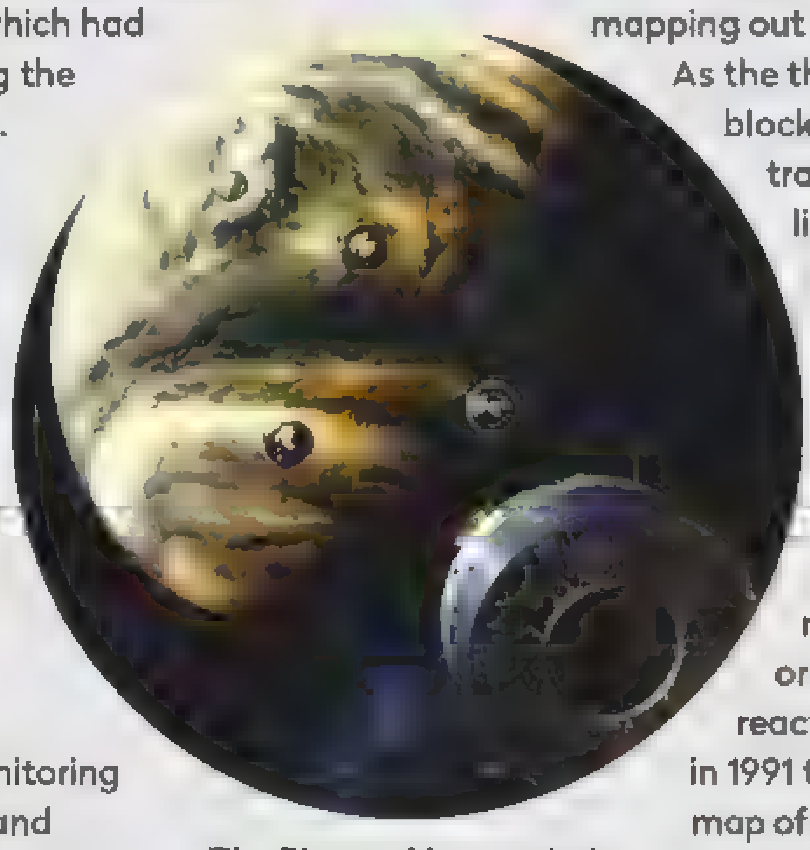
6 August 1980

In August 1980's episode of *The Sky at Night*, Patrick Moore discussed the results from NASAs Pioneer Venus Mission, which had finished mapping the surface of Venus.

Pioneer Venus entered the planet's orbit in December 1978. Upon arrival, the spacecraft dropped off four atmospheric probes, which descended through Venus's atmosphere, monitoring its composition and motion as they fell. Though they weren't designed to land on the surface two survived impact and one transmitted for over an hour before succumbing to the crushing pressure of the atmosphere.

The orbiter then spent several years mapping out Venus's surface. As the thick clouds blocked the view of traditional visible light cameras, the spacecraft used radar to chart the planet's mountains and valleys.

The spacecraft remained in orbit for 12 years, reactivating its radar in 1991 to create a better map of the southern and polar regions, and to augment NASA's newer Magellan spacecraft. Pioneer Venus met its end in 1992, when it crashed into the Venusian atmosphere.



▲ The Pioneer Venus mission launches smaller probes to investigate the surface in 1978

ESA mission selection

Only a handful of missions are sent into space every decade, so how do space agencies decide which are cleared for launch and which are grounded? This month *The Sky at Night* goes behind the scenes as ESA selects its next F-class mission, for launch in 2028. The team meet UK teams vying to have their ideas selected, including a mission to a comet.

BBC Four, **11 August,** 10pm (first repeat BBC Four, **15 August,** 7.30pm)
Check www.bbc.co.uk/skyatnight for subsequent repeat times

▲ **A planned UK-led ESA mission would see a spacecraft sent to an interstellar comet**

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

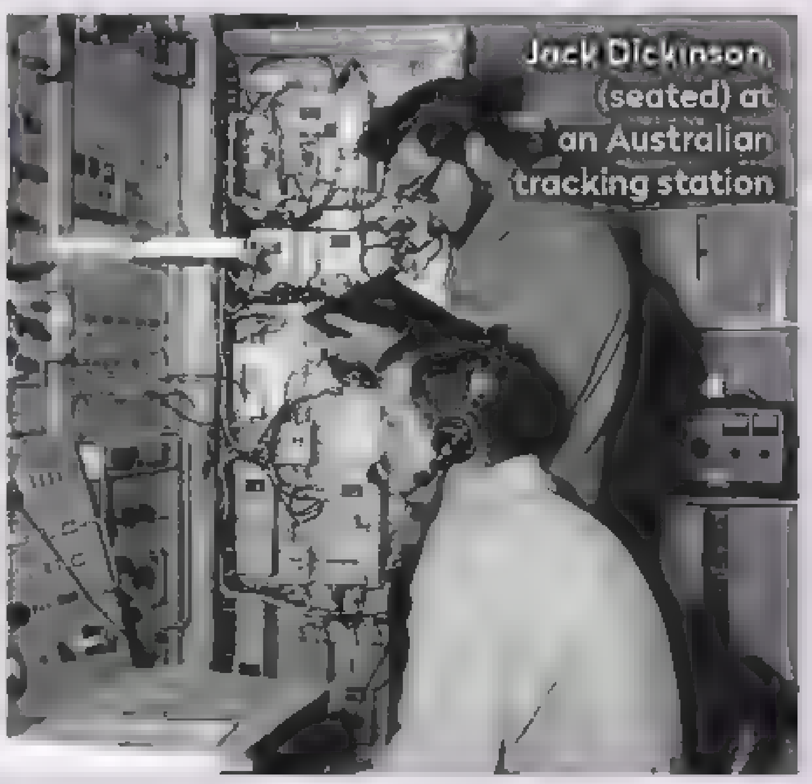
This month's top prize: four Philip's books

PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH

My father helped Apollo



Jack Dickinson (seated) at an Australian tracking station

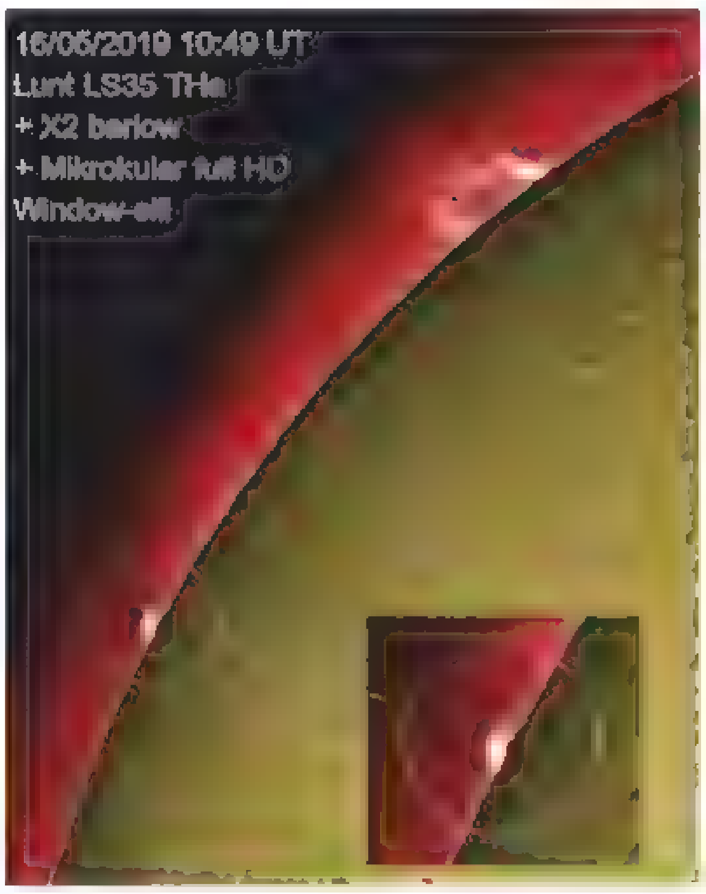
I was five at the time of the Apollo 11 Moon landings and my father wasn't home because he was supporting the landing as a radio frequency technician at Honeysuckle Creek Tracking Station in Australia, receiving the signal from Apollo. On the night of the Moon landing, friends from my preschool came to our house and we sat round the TV. I remember being very proud of my father even though I didn't understand how he was helping. Over the years, he worked on all the Apollo missions including supporting the Apollo 13 recovery from the Parkes dish, as well as the Viking Mars missions, Pioneer and Voyager. I have lasting memories of pestering him about space travel, black holes, and astronomy while drying the dishes as he washed up.

John Dickinson, via Facebook

Truly magical memories, John! Thank you for sharing your family connection to Apollo 11. *– Ed*

Tweets

Stace
@AstroStace • Jun 22
Night and day, two images both captured 1 day either side of the summer solstice! Here we have the Western Veil Nebula and our local star, the Sun! #Astronomy #Astrophotography @BBCStargazing @skyatnightmag #backyardastronomy



In the loop

A few months ago you featured my images of an odd solar phenomenon (Interactive, April 2019) and concluded that it was an "active flare caught in a rare loop phase". Well, I seem to have another one! This one was imaged on the morning of 16 June, again from my 'Windowsill Observatory', through gaps in the clouds. Making use of the National Solar Observatory's Global Oscillation Network Group data to check the event, I was able to make out a prominence on all the frames but only one taken at 10:49 UT contained a loop. This corroborates my image and also the very short-lived nature of the event. Maybe these loop phases are not so rare after all!

Roger Samworth, Nuneaton

To 3D or not 3D

In reply to Chris Webster (Interactive, July 2019) I'm sorry to say that even the nearest stars are too far away to discern them in 3D. However, with very sensitive photographic equipment it is possible to measure the extremely small shift in parallax exhibited by nearby stars. It is interesting to note that with binoculars, ▸

sometimes the illusion of 3D is experienced.
Terry Byatt, Holbeach

Barflies

I work at Swan Brewery in the north of Herefordshire, and I think the stars lined up to show us the way for a couple of our new summer beers. In a brainstorm about what to call them, we came up with Swan Small Step and Swan Giant Leap – of course to mark the 50th anniversary of the first manned Moon landings. When planning recipes, our head brewer came across hop varieties Apollo, Comet, Eagle, Flyer and Orbit, so they had to ▸

ON FACEBOOK

WE ASKED: What are your memories of the Apollo 11 Moon landing?

Allan Mcmillan
I was visiting a friend's cousin at the time. We sat all day and most of the hot summer night quenching our thirst for knowledge in a pub as guests of the landlord. The pub in Kings Norton, Birmingham, was renamed the 'Man on the Moon', and remains so to this day. We watched the Apollo 11 mission on the big lounge TV.

Marc Mayerson
The night of the Moon landing, we went to see The Fifth Dimension at the Los Angeles Greek Theatre. Underneath the Moon and stars, they opened the show with *Age of Aquarius*, dedicated to our brave astronauts – a magical song for a magical moment.

Alan Stewart
I was 13 years old, on a school trip to Dinard in Brittany. We watched the landing on a tiny black and white TV in the hotel lounge. In the town, crowds gathered to watch a TV in one of the shop windows. Exciting times!

Andrew Grasemann
I was not allowed to stay up and watch the Moon landing. I was 10 and my argument that it was history in the making, did not go down with my mother who said "it will still be history tomorrow".

John White
I'd just graduated from Queens' Cambridge and was in a tent with my friends in Glen Brittle on the Isle of Skye listening to the landing on my transistor radio pressed against my ear trying not to disturb the others.

Drew Sams
I was sitting in front of our black and white TV with my parents, thinking "this is boring, can't we watch *Batman*?" I was aged seven.

Marian Smith
I was 18 and watched it with my then boyfriend. We've now been married 47 years, but I remember it clearly.

Angie Jukes
I was a four-year-old being told by my brother "you'll want to remember this". Parquet flooring pressed into my legs as I was sitting cross-legged watching a grainy image. "Tranquillity Base. The Eagle has landed" meant nothing to me at four but it raises hairs every time I hear it!

Paul Adamson
I was 11 and watched the Moon landing live on a Sunday evening in the UK. Now, I'm chairman of a local astronomy club and we're holding an Apollo exhibition on 20 July.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies
With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I own a Sky-Watcher 200P Explorer telescope. Would a Celestron Nexstar 8SE be a good upgrade for planetary observing?
RAYMOND COLLINS

Celestron's Nexstar 8SE allows twice as much magnification

The Sky-Watcher 200P Explorer is a Newtonian reflector with a focal length of 1,000mm, whereas a Celestron NexStar 8SE has a focal length of just over double that at 2,032mm. This means that the magnification available with any given eyepiece will be twice as high with the Celestron.

Planetary observing is best achieved using high magnifications as the objects of interest are relatively small so a Schmidt Cassegrain telescope like the NexStar 8SE would be a great choice for your purposes.

The NexStar's single-arm altazimuth mount is substantial enough to carry the weight of an 8-inch telescope well, but it is likely that just touching the scope will disturb the view, so any movement will take a few seconds to dampen down. It would be well worth considering the addition of an electronic motor for the focuser so that focusing can be carried out without physically touching the telescope – that way you limit the chances of vibration.

Steve's top tip

What is a dark frame?

During the long exposures required for many deep-sky images, the sensor warms up, generating 'thermal noise' in the images. This noise tricks the sensor into believing that it has received some additional photons. Among other unwanted artefacts this can result in a peppering of white pixels across the image looking rather like tiny stars.

Dark frames are images taken with the telescope capped, using exposures of the same length and camera temperature as your main images. They contain just the thermal noise as no actual light has reached the sensor. Subtracting these special images from your normal images using software like DeekSkyStacker or Photoshop removes the sensor noise.

Steve Richards is a keen astro imager and an astronomy equipment expert

BBC Sky at Night MAGAZINE

BBC Sky at Night Magazine is published by Immediate Media Company Bristol Limited under licence from BBC Studios, which helps fund new BBC programmes.

EDITORIAL
Editor Chris Bramley
Art Editor Steve Marsh
Production Editor Neil McKim
News Editor Elizabeth Pearson
Staff Writer Iain Todd
Reviews Editor Paul Money
Editorial Intern Daisy Dobrijevic

CONTRIBUTORS
Shaoni Bhattacharya Paul Cockburn, Adam Crute, Lewis Dartnell Glenn Dawes Ben Evans, Jane Green, Deirdre Kelleghan Tim Jardine Pete Lawrence, Chris Lintott, Paul Money Chris North Mark Parrish Rod Pyle Katrin Raynor-Evans, Steve Richards, Steve Sayers, Niamh Shaw, Stephen Tonkin, Emily Winterburn, Paul Wootton

ADVERTISING SALES
Advertising Managers
Neil Lloyd +44 (0)117 300 8276
Tony Robinson +44 (0)117 314 8811
Inserts Laurence Robertson +353 (0)87 690 2208

PRODUCTION
Production Director Sarah Powell
Production Coordinator Derrick Andrews
Ad Services Manager Paul Thornton
Ad Coordinator Georgia Tolley
Ad Designers Cee Pike, Andrew Hobson
Reprographics Tony Hunt, Chris Sutch

LICENSING
Director of Licensing and Syndication Tim Hudson
International Partners' Manager Anna Genevier

MARKETING
Head of Circulation Rob Brock
Head of Marketing Jacky Perales-Morris
Marketing Executive Craig Ramsay
Press and PR Manager Emma Cooney

PUBLISHING & MANAGEMENT
Publisher Jemima Dixon
Managing Director Andy Healy
Group Managing Director Andy Marshall
CEO Tom Bureau

BBC STUDIOS, UK PUBLISHING
Chair, Editorial Review Boards Nicholas Brett
Director of Consumer Products and Publishing Andrew Moultrie
Head of Publishing Mandy Thwaites
UK Publishing Coordinator Eva Abramik
UK.Publishing@bbc.com

EDITORIAL REVIEW BOARD
Andrew Cohen, Head BBC Studios Science Unit; Deborah Cohen Editor, BBC Science Radio, Steve Crabtree Executive Producer, BBC Studios; Carmen Pryce; Robin McKie

SUBSCRIPTION RATES
Annual subscription rates (inc. P&P): UK cheque/credit card £62.40; Europe & Eire Airmail £75, rest of world airmail £85. To order call 03330 162119 (UK); overseas +44 (0)1604 973727

IPSO Regulated
We abide by IPSO's rules and regulations. To give feedback about our magazines, please visit immediate.co.uk email **editorialcomplaints@immediate.co.uk** or write to The Editor *BBC Sky at Night Magazine* Immediate Media Co. Eagle House Colston Avenue Bristol BS1 4ST.

Audit Bureau of Circulations
19 202 (combined; Jan–Dec 2018)

ISSN 1745-9869

▸ be included. Local publicans have been chuckling at the names and coming up with pun-laden ripostes: "They'll go like a rocket." And, "Everyone says there's no atmosphere in here."
Gill Bullock, Swan Brewery, Leominster

Solar solution

I recently made a white light solar filter and then saw Mr Horrox's arrangement for a solar alignment aid (Interactive, June 2019). Having no solar film left over from the main project, I came up with an alternative solar aligner made out of card, glue and lined paper. The design is similar to the main solar filter in that it slips over the objective end of the finderscope. When correctly aligned, the Sun's rays line up at 90° to the slot, are parallel to the 90° lines on the paper and shine on the screw in the finder's bracket. When mis-aligned, the light is either not parallel or does not show at all. Perhaps this could be useful to your readers.
David Penny, via email

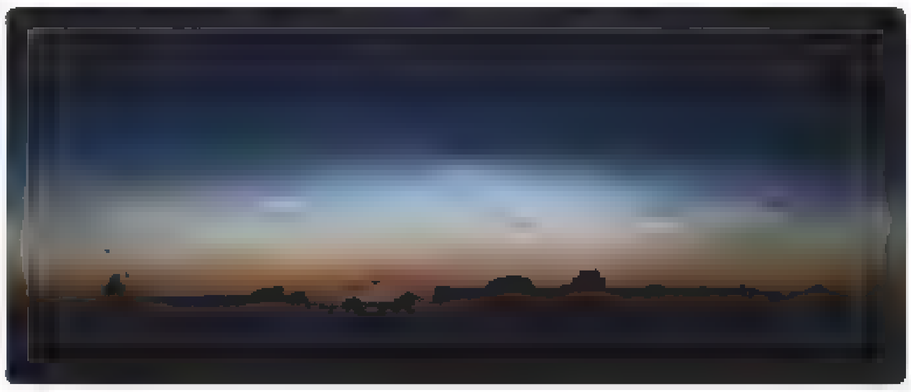
Ringside view

I've always been interested in astronomy and after watching a *Stargazing Live* episode some years ago I became a fan of Brian Cox. Thanks to *BBC Sky at Night Magazine* I was inspired to purchase my first scope, which on one lucky evening enabled me to view Saturn and its amazing rings. It was one of the most magical moments of my life. I still enjoy viewing the Moon but to see Saturn millions of miles away was breathtaking. As a result I purchased a Canon DSLR camera with filters and connections to try my hand at astrophotography. Your June edition offered a lot of helpful information.

Hopefully, the next time I see Saturn, I'll be able to capture the moment and share it with you. Thank you for inspiring me to start this exciting journey to capture the stars!
Emma Newey, via email

Tweets

Derek Mitchell
@sideburns1970 • Jun 28
#noctilucentclouds #Glasgow #StormHour @skyatnightmag



SOCIETY IN FOCUS

Friday night is open night at the Rosse Observatory, Pontefract, home of West Yorkshire Astronomical Society (WYAS). We welcome new visitors and members, the external pad and dome are always available (weather permitting) and a WYAS member is on hand to help with anything astronomical. Friday 24 May saw the first monthly meeting for young astronomers, and we welcomed 24 children aged between four and nine with parents, grandparents, aunties and uncles to take part in an evening of astronomical activities.

Activities for week one were all about the Moon, and included lunar phases, making straw rockets and Moon snacks, creating craters using flour, cocoa powder and tiny impactors, solar observing and looking at our telescope in the dome. The adults really got into the spirit and helped the children prepare models during what was a very enjoyable evening. Future young astronomers' evenings will be focusing on the Sun, the planets and the constellations.

WYAS formed in 1973 is open to members and non-members alike and meets on Tuesday and Friday evenings from 7.15pm.
www.wyas.org.uk
Terry Dobson, vice chairman, West Yorkshire Astronomical Society

Our pick of the best events from around the UK

WHAT'S ON

The Story of the Solar System

Bacon Theatre, Cheltenham, 17 August

Astronomer Will Gater explores the story of the Solar System. The show contains imagery and videos from recent space missions, live science demonstrations and audience participation. Tickets are £12. To book visit **www.bacontheatre.co.uk**

Salford Stargazing

Salford Observatory, Chasely Fields, 7, 14, 21 & 28 August, 7:30pm–9:30pm

An evening of stargazing and observing through telescopes, with the Salford Astronomical Society. Weather dependent, check with organisers before travel. For further information visit **www.salfordastro.org.uk/Salford_Astronmical_Society/Home.html**

Summer Astronomy Evening

Royal Observatory, Edinburgh, 9 August, 6:30pm & 8pm

Discover the story of Edinburgh's Royal Observatory at a public astronomy evening. Each session lasts one hour. Tickets are £5 adults, £4 concessions and children. To book, visit **www.eventbrite.co.uk/e/summer-public-astronomy-evening-tickets-57193829283**

PICK OF THE MONTH

▲ Join the celebration of all things astronomical in the heart of the Welsh countryside

Solarsphere 2019

Penmaenau Farm, Powys, 9–12 August

The family friendly astronomy and music festival returns to the Welsh countryside. The star camp welcomes everyone from beginners to experts, in an environment that aims to educate the curious.

Festivalgoers can experience a host of different talks, live music, solar and night sky observing workshops, and crafts. All evening events are held inside to avoid light pollution.

This year's speakers include astronomer and broadcaster Peter J Williamson, *BBC Sky at Night Magazine* contributor Steve Tonkin, Tim Gregory from BBC TV series *Astronaut: Do You Have What It Takes?* and award-winning science populariser Nigel Henbest.

Explore further with the cosmos planetarium, learn about astro-drawing with Mary McIntyre, dive into the world of binocular astronomy with Steve Tonkin and take part in workshops hosted by AstroCymru over the weekend.

Tickets are £50 (adults), £25 (for ages 13–16) and free for under 13s. Prices include access to the festival, camping and some workshops. For more information, see **www.solarsphere.events**

Perseid Pig

Curly Tails Pig Sanctuary, Bletchley, 17 August, 6pm–late

Join UK Astronomy and The Curly Tails Pig Sanctuary for a piggy meet and greet and solar gazing through specialist equipment. Tickets are £15 with limited spaces. To book, email **info@curlytails.org**

Solar Gazing

Abberton Reservoir, Colchester, 24 August, 12pm–3pm

The North Essex Astronomical Society and the Essex Wildlife Trust combine for an afternoon of solar gazing with specialist telescopes. For more information visit **www.northessexastro.co.uk/events/**

Night Sky Experience

Scottish Dark Observatory, Dalmellington, 29, 30 & 31 August, 9pm–10:30pm

Explore the SDOS with a presentation guided stargazing through a scope (weather permitting) and tour. Tickets: £16 adults £12 concessions and £10 children. **www.scottishdarkskyobservatory.co.uk**

WILL GATER, SOLARSPHERE X 4

The amateur astronomer's forum

FIELD OF VIEW

One giant leap... for Bristol

Having been fascinated by Apollo 11, a combination of luck, letter-writing and impulse helped **Richard Phillips** meet his hero, the astronaut Neil Armstrong

Richard Phillips shares his fascination for the Apollo Moon landings with group talks to young and old alike. Find out more at **www.apollotalks.co.uk**

The Apollo Moon landings have always inspired me, no more so than when I was nine years old and my father gently coaxed me out of bed in the early hours of the morning, to watch our black and white television set as Neil Armstrong and Buzz Aldrin landed on the Moon.

Some 40 years later, after work one day and on a whim and a prayer, I drove from Bristol for three hours and 300km to a US airbase in Suffolk, in the hope that I would see the first man on the Moon. Once I had managed to blag my way past a cluster of machine-gun wielding security guards, I found myself standing in a room looking at Neil Armstrong.

He was there to deliver a motivational talk to the American service personnel. And then, without any real planning, I got lucky: I had somehow managed to position myself in the exact spot where Neil was to exit the room. As I held out my hand he was gracious enough to shake it.

That was in March 2010. In the months following I thought how great it would be to spend a whole day with him – this time without having to drive so far. By November I had a plan and so, taking direction from James Hansen's biography *First Man*, I wrote him a letter.

"Dear Mr Armstrong," it began. "On the understanding that first and foremost you are an engineer, you may well be interested in a visit to Bristol to..." The letter went on to invite him to my home city of Bristol for the day to see Isambard Kingdom Brunel's iconic steam ship, the *SS Great Britain*, followed by a visit to the building next door to meet the team behind Bloodhound SSC (Super Sonic Car), the project to break the world land speed record, which was based there at the time.

I crafted the letter to appeal to a reserved and unassuming 80-year-old man, assuring him of his complete privacy: "There will be no involvement from the press whatsoever and no expectation for autographs or indeed any pressure for photos during the visit." I kept my word to Neil.

I was very surprised that he read the letter, which was posted to a PO Box in Lebanon, Ohio on 2 November 2010. And it was surreal, to say the least that just 26 days later on 28 November, my elder son Charles and I spent the whole day with him on Bristol's Floating Harbour.

Little did I realise that I would be introducing Neil to his hero. As we walked around the *SS Great Britain* and the museum, Neil would refer to him as Isambard, and he reeled off numerous facts and figures about his other achievements: "Did you know, Richard, that Isambard's other ship, the *SS Great Eastern*, was 692 feet long and...". Clearly Neil greatly admired the great engineer.

I imagine that if they had actually met one another, Neil and Isambard would have become great friends. It is great to know that at least in spirit, on that day in Bristol in November 2010, Neil Armstrong met his very own hero.

HIFUMIYO/FOLIO ART

APOLLO 11

50 years ago a man took one small step onto another world. **Elizabeth Pearson** looks back at the mission that made history

On 16 July 1969, Cape Kennedy was filled with hundreds of thousands of people, pouring into the area in cars, buses, boats and planes. Most came to cheer, a few to protest, but everyone who gathered on the Cape that day knew that they were about to bear witness to one of the biggest moments in human history. Apollo 11 was about to launch on its way to land the first ever humans on the Moon.

At 9:23am local time, the bright light of a rocket began to glow on the horizon, slowly rising up into the sky. While people on the ground cheered and burst into tears, for the three astronauts on top of the Saturn V rocket, things were much more subdued. While previous Apollo missions had been fairly light-hearted, everyone knew this was the big one. Gone were the candy and cartoon themed names for the command module and lunar module – the crew of Apollo 11 had given theirs the patriotic names Columbia and Eagle respectively. Three hours after launch, the spacecraft left Earth orbit and began the three-day journey to the Moon.

The previous Apollo missions had rehearsed the procedures for lunar transit, so they were now familiar. First, the crew gave the Eagle its wings by extracting the lunar module from its launch position behind Columbia, allowing them to move between the two. The trio spent the rest of the journey checking over every system and preparing their gear, only stopping to eat, sleep and make the occasional colour TV broadcast, bringing all of humanity along on the adventure.

> "One small step for [a] man, one giant leap for mankind."
> – Neil Armstrong

Ready for descent

The crew arrived in lunar orbit on 19 July, and then all too quickly the big day came around. On 20 July, 100 ▸

MISSION BRIEF

Launch date: 16 July 1969

Launch location: Launch Complex 39 A

Landing location: Sea of Tranquillity

Time on surface: 22 hours, 37 minutes

Duration: 8 days, 3 hours, 18 minutes

Return date: 24 July 1969

Main goals: land humans on the Moon and return them to Earth, gather rock samples, deploy lunar laser ranging experiment

Firsts: human landing on the Moon, first moonwalk

Menu: Bacon cubes, sugar cookies, peaches, pineapple grapefruit drink, coffee

NASA X 13

Making a mark: Buzz Aldrin photographs his boot on 21 July as he makes an imprint in the dust of the lunar surface

▸ hours and 12 minutes after leaving Earth, Commander Neil Armstrong and lunar module pilot Buzz Aldrin crossed over into Eagle and undocked from Columbia. Their destination – the lunar surface.

For two and a half hours, the descent towards their selected landing site in the Sea of Tranquillity went smoothly. Aldrin kept an eye on the instruments, reading off seemingly impenetrable strings of numbers, which Armstrong was able to decode to guide the lander down to the surface. Then five minutes before they were due to touch down, when they were 9,000m away from the surface, an alarm went off.

Neither Aldrin nor Armstrong had ever come across the error, a 1202, in their training. Ground control had no idea what the error code meant either. Should they abort? At this late stage aborting would be a dangerous option. A few moments later, while mission controllers were still frantically looking up the error in their manuals, a second alarm went off. Feeling the weight of the world urging them to complete the landing, mission controllers scrambled to reach a judgement on whether to abort. It was guidance officer Steve Bales, acting on the information of back-room specialist Jack Garman, who told the capsule communicator Charlie Duke in Houston that he could give the all clear: "We're 'Go' on that alarm," came the call to Eagle.

While Aldrin was trying to sort out what would turn out to be a minor software fault, Armstrong had his own problems. They had overshot the predicted landing zone. Instead, they were approaching a vast crater field littered with car-sized boulders – if they tried to land now they would almost definitely crash.

The dial indicated there was just one minute of fuel left in the tank before they would be forced to either land or abort, if an abort was even possible this close to the surface. Armstrong levelled off the descent, skimming just over 100m across the surface, looking out from the window for a place to land.

Touching down

With less than 30 seconds of fuel left, the commander found a smooth spot on the grey landscape below. As he neared the surface, the engines threw up dust. Armstrong flew the last few metres blind, waiting for the blue 'contact light', indicating the lander leg had touched the surface. It came on: the Eagle had landed.

▲ Above left: the Saturn V rocket that would carry the astronauts into Earth orbit begins its slow rollout to the launch pad. Middle: Neil Armstrong's EVA suit is laid out for inspection. Right: on 16 July launch team members watch the lift-off of Apollo 11

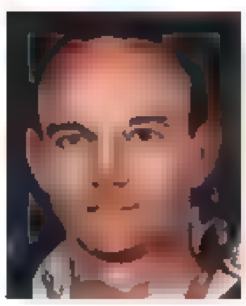
▲ After undocking for its descent to the Moon, the lunar module Eagle is photographed by Michael Collins from inside the command module on 20 July

NASA X 8, ILLUSTRATION BY PAUL WOOTTON

Meet the astronauts

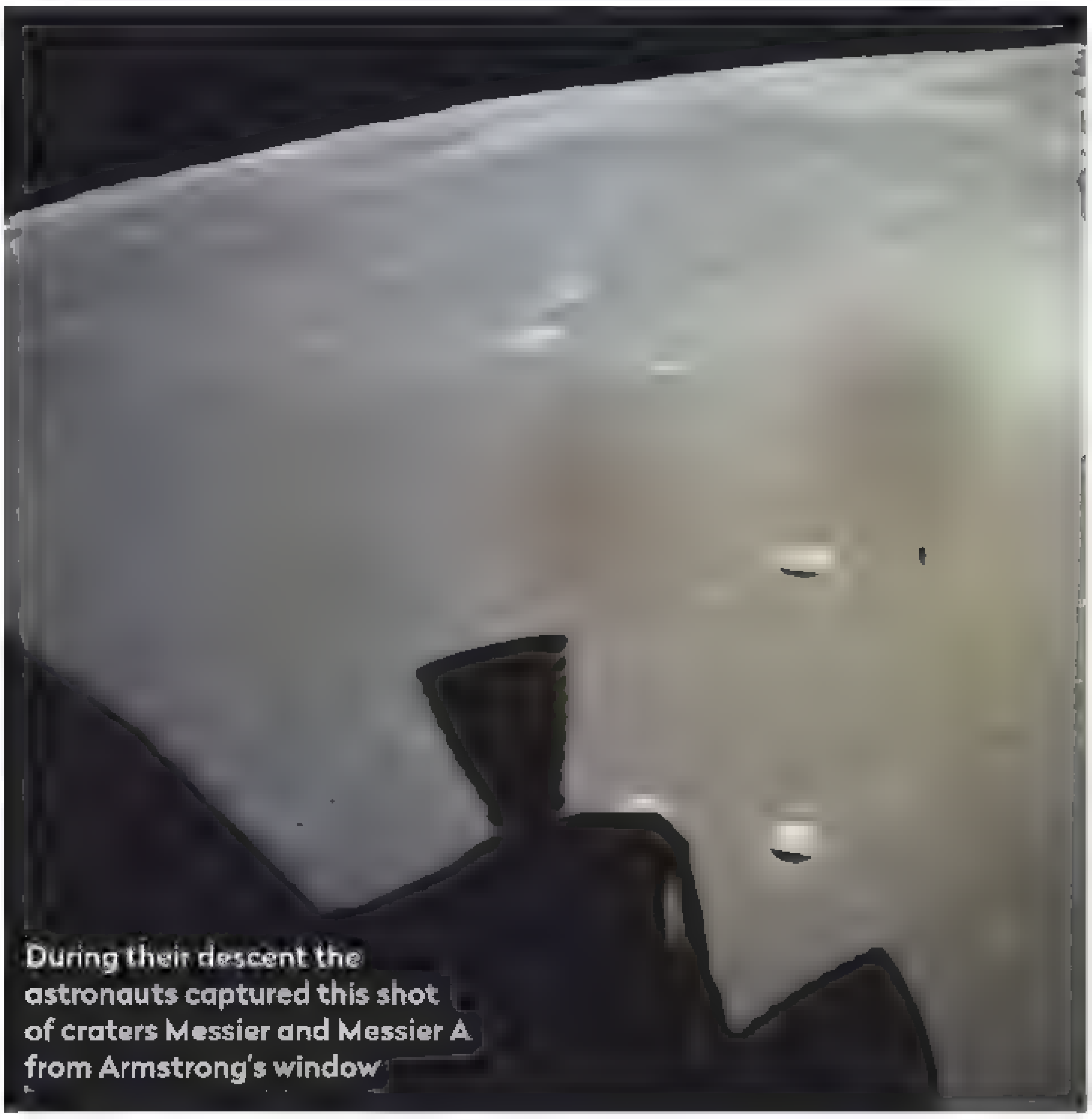
Commander: Neil Armstrong
Armstrong was born on 5 August 1930. He entered the US Navy in 1949, later becoming a test pilot. He joined the second group of astronauts in 1962, making his first spaceflight on Gemini 8. He left NASA after Apollo 11 to become a teaching professor at the University of Cincinnati. He passed away on 25 August 2012.

Lunar module pilot: Edwin 'Buzz' Aldrin
Born on 20 January 1930, Aldrin spent his early life in the US Air Force before joining NASA. He took part in Gemini 12, where he conducted a five-hour EVA. He left NASA in 1971 but remains a space advocate. He is involved in promoting the exploration of Mars, having developed plans which could accomplish the feat.



Command module pilot: Michael Collins
Born on 31 October 1930, Collins initially joined the United States Air Force. He became a test pilot before joining NASA in 1963. Collins flew on Gemini 10 in 1966, a three-day mission which practised rendezvous in orbit and conducting EVAs. After Apollo 11 he became director of the Smithsonian Institute's Air and Space Museum.

Apollo 11's flightplan shows how it successfully travelled to the Moon and back half a century ago



During their descent the astronauts captured this shot of craters Messier and Messier A from Armstrong's window

Disaster almost struck a third time when ice blocked a fuel line shortly after landing. Fearing that the build-up of pressure could damage the ascent engines and prevent take off the crew prepared to abort, but were able to clear the line before anything ruptured.

The pair were scheduled to rest for a few hours before the moonwalk, but how could they sleep knowing they were on the verge of one of the most anticipated events in human history? Four hours after landing on the surface, the pair were ready to head outside.

Back on Earth, one fifth of the world's population watched the images being sent from a camera suspended beneath the lander, showing the bottom rungs of the exit ladder. Slowly, the blurry shape of Armstrong emerged into view, accompanied by the astronaut's voice narrating his descent. At the bottom of the ladder, the world held its breath as Armstrong paused for a moment before planting humanity's first footprint on another world with the words, "That's one small step for [a] man, one giant leap for mankind."

Twenty minutes later, Aldrin joined Armstrong on the surface, proclaiming it to be a, "Beautiful view. Magnificent desolation." ▸

▲ The Eagle has landed: Aldrin sets foot on the lunar surface – as one of the first humans to walk on the Moon

NASA X 7

▶ The lunar landscape appeared truly alien to the astronauts. "I was surprised by the apparent closeness of the horizon," Armstrong said to NASA historians years later. With no atmosphere to diffuse the light, judging distance on the Moon became difficult and the dust behaved very oddly. "I was surprised by the trajectory of dust that you kicked up with your boot... You never had a cloud of dust there."

The astronauts weren't there to admire the view, however; they had a job to do. Armstrong's first task was to collect a bag of dust as a contingency, in case an emergency evacuation prevented them from a scheduled collection of rock samples. Next, they deployed the science experiments, including an instrument examining the solar wind and a reflector which could be used to measure the distance between Earth and the Moon to within an accuracy of centimetres.

America first: Aldrin salutes the US flag

Time to go

Afterwards Armstrong and Aldrin set up a plaque, stating that they 'came in peace for all mankind', before planting a US flag to highlight which nation had achieved the historic feat. Unfortunately, the ground was so hard that Armstrong couldn't get the pole in more than a few inches, and it fell over when they fired the ascent engine on leaving the lunar surface.

When the time came to collect rock samples, the mission was rapidly approaching its end. The pair grabbed what Moon rocks they could, throwing them into sample bags with no time for full cataloguing, then hoisted them back onto the lander. After just two hours on the surface, the pair climbed back into Eagle and resealed the hatch. Humanity's first foray onto another world was over.

"I'd like to ask every person listening in... to pause for a moment and contemplate the events of the past few hours." – Buzz Aldrin

MISSION TIMELINE

16 July 13:32*
Apollo 11 takes off from Cape Kennedy, Florida.

19 July 17:21
After three days in transit, the crew arrive in lunar orbit.

20 July 17:44
Eagle undocks from Columbia and begins its descent to the Moon's surface.

20 July 20:17
A rod on the lunar module's leg indicates that the Eagle has touched down. The landing site is named Tranquillity Base.

21 July 02:39
Buzz Aldrin struggles to open the hatch, and peels back the seal to release pressure inside the lander.

21 July 02:56
Armstrong steps onto the lunar surface stating, "That's one small step for [a] man, one giant leap for mankind."

21 July 05:11
Aldrin and Armstrong close the hatch after returning to the lunar module.

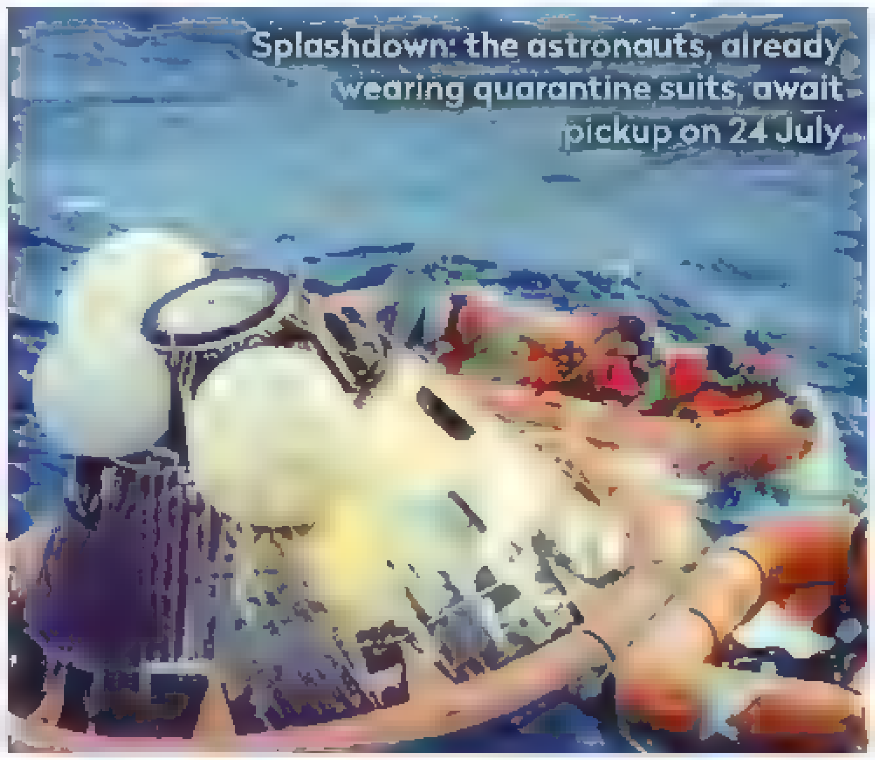
21 July 17:54
Eagle takes off from the Moon's surface to reunite with Columbia in orbit.

24 July 16:50
Splashdown in the Pacific Ocean. Crew rescued by USS Hornet and confined to quarantine.

*All times are UT

Close horizon: Aldrin bunny hops across the lunar surface, his arms laden with science experiments

Overjoyed: Armstrong, pictured inside the lander just after completing the EVA



Splashdown: the astronauts, already wearing quarantine suits, await pickup on 24 July

Back in orbit, command module pilot Michael Collins had been keeping Columbia running, orbiting the Moon 12 times as he waited for his colleagues to return. In his memoir, *Carrying the Fire*, he recalled those few moments every orbit when he passed behind the Moon and lost contact with Earth: "I am alone now, truly alone, and absolutely isolated from any known life. I am it. If a count were taken, the score would be three billion plus two over on the other side of the Moon, and one plus God knows what on this side."

Aldrin and Armstrong left the lunar surface 21 hours and 38 minutes after landing, and reunited with Collins to begin the journey home. Three days later, on 24 July, the capsule splashed down in the Pacific off the coast of Hawaii, and was picked up by the USS Hornet. However, rather than receiving a hero's welcome and red-carpet treatment, the trio were doused with disinfectant and locked in quarantine for three weeks in case any dangerous Moon bugs had hitchhiked home with them.

President Nixon conveyed the feelings of the world as he spoke to the crew through a window. "It has only been eight days," he said. "Just a week, a long week. But this is the greatest week in the history of the world since the Creation. The world is bigger, infinitely."

In July the BBC Two drama documentary *Eight Days* relives the excitement of Apollo 11, combining declassified cockpit audio from 1969 with today's special effects and performances. *See BBC iPlayer for details.*

Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University

Destination Moon: humans may be back in lunar orbit within a few years

Return TO THE MOON

We are on the cusp of a new era of lunar exploration, with new players, as **Niamh Shaw** discovers

The days of the Space Race between the Soviet and US superpowers are long gone. Fifty years after Apollo, we're in a new, more competitive dawn of lunar exploration, this time featuring players from all over the world. For example, on 11 April this year, the Beresheet robotic spacecraft – the first privately funded Israeli mission – attempted a lunar landing. While their effort crashed, it did reach the surface and proved that any country, any company, no matter how small, can participate in lunar missions. You just need the budget, know-how and drive to succeed.

Larger commercial space companies such as SpaceX and Blue Origin have shared plans of their autonomous lunar missions. Moreover, they are not alone. China and India are growing space powers and more nations are continuing to emerge. An exciting time is upon us and launch schedules are getting busy, as everyone is racing back to the Moon.

Earlier this year, the China National Space Administration successfully launched its Chang'e 4 lunar lander to the South Pole Aitken basin on the Moon's far side and deployed its Yutu 2 Rover. Using the knowledge that they gained from this mission, they are developing technologies for their later Chang'e 5 and 6 stages. These are all part of an extensive lunar exploration programme, the ultimate goal of which is to perform a crewed mission landing in the 2030s to establish a permanent Chinese outpost near the South Pole. ▸

WALTER MYERS/SCIENCE PHOTO LIBRARY

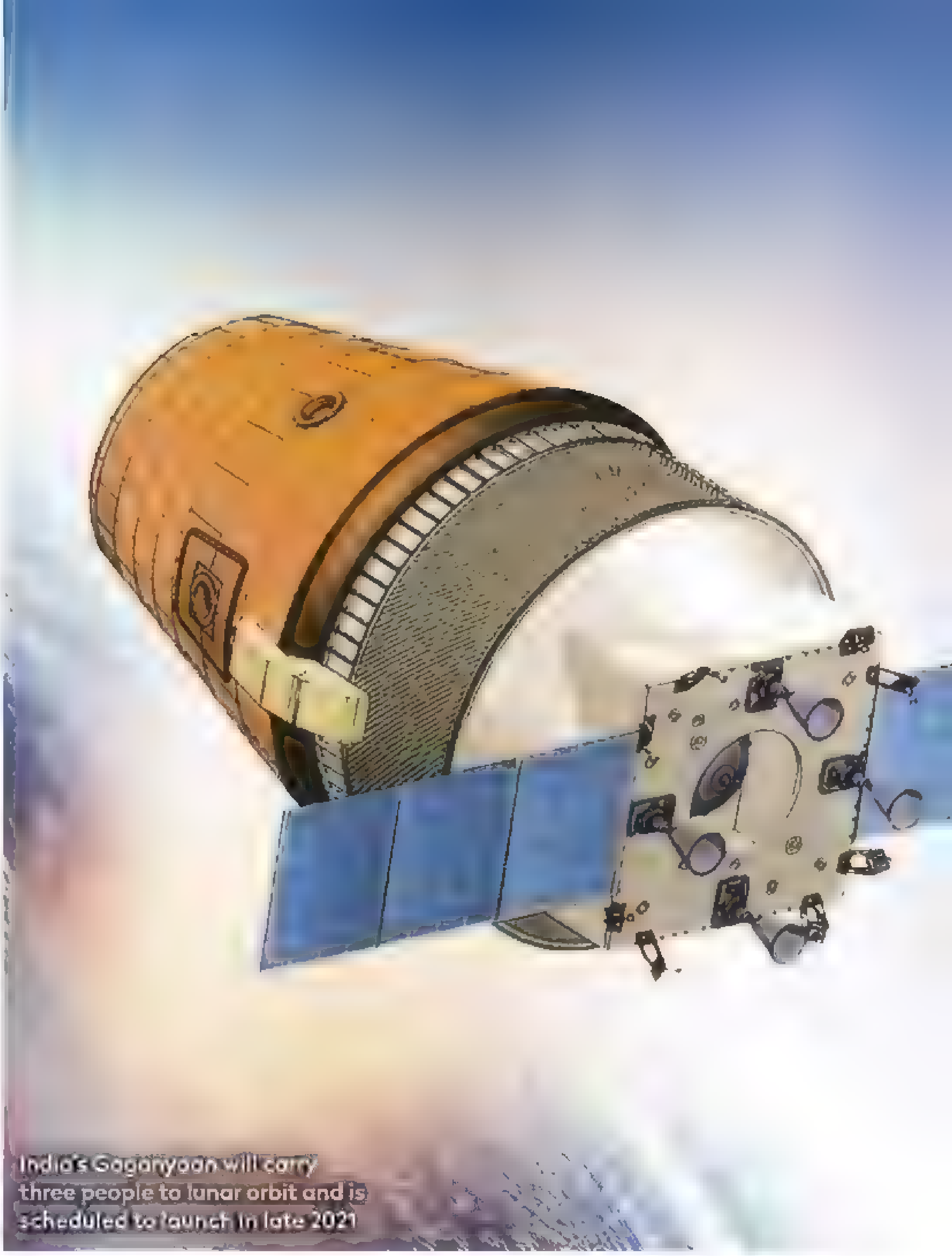
▸ India's Chandrayaan-2, which (at the time of going to press) has a launch date of 15 July, will be the second mission to the Moon for the nation. Including an orbiter and lander-rover module, IRSO aims to gain a better understanding of the origin and evolution of the Moon with the mission. Like China, India offers to have a human space programme and a crewed orbital vehicle, called Gaganyaan. Designed to carry three people, ISRO plans on launching this three-person mission to orbit the Moon for seven days, in late 2021.

Equal players

With this rapid activity from these emerging space players, the playing field has been levelled. The larger, more established agencies such as NASA and Russia's Roscosmos are now pitched equally against these smaller agencies, who are each making their claim on the Moon.

Roscosmos is planning a series of lunar robotic missions. Firstly, the Luna-25 mission, due to launch in 2021, aims to land near the lunar south pole and analyse regolith samples. Then the Luna-26 mission will study the Moon from low polar orbit and finally, the Luna-27 landing mission will partner with ESA

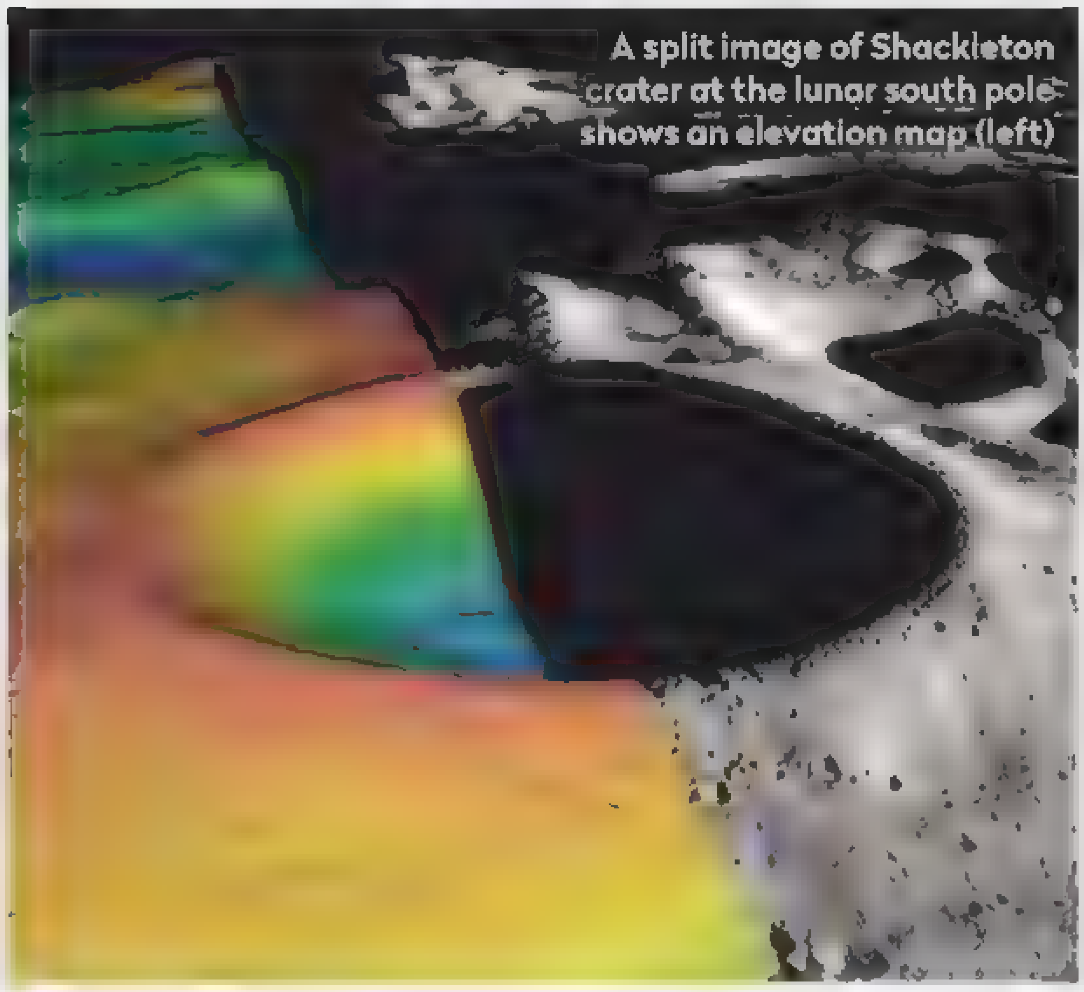
DEAN SMITH, NASA/ZUBER/M T ET AL/NATURE/2012, WALTER MYERS/SCIENCE PHOTO LIBRARY



India's Gaganyaan will carry three people to lunar orbit and is scheduled to launch in late 2021

Why are we going back?

The scientific and business cases for returning to the Moon

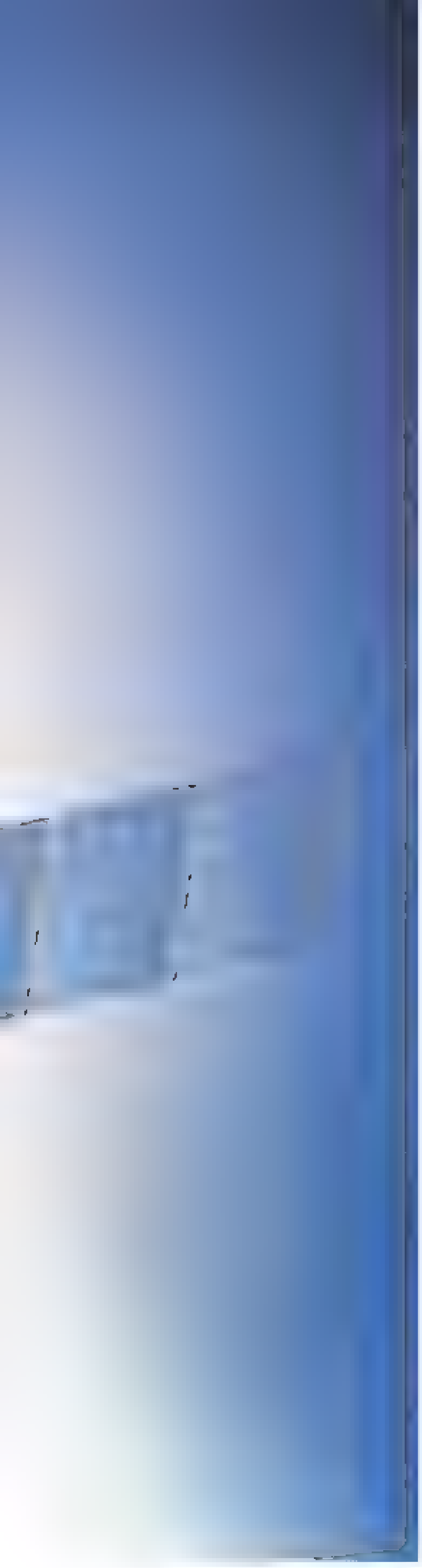


A split image of Shackleton crater at the lunar south pole shows an elevation map (left)

The South Pole crater has been selected for exploration by many space players. As ESA's Didier Schmitt explains, "We know that it is rich in water resources, which we can hydrolyse for propellant (as hydrogen) and oxygen for the crew. Also, the South Pole has collected all the material from the interior of the Moon when it cooled some 4 billion years ago. Such craters are cold traps that contain a fossil record of the early Solar System. We can learn a lot about our origins."

"A key strategy to the successful location of a permanent base will be in situ resource utilisation (ISRU)," says Aidan Cowley, ESA science advisor to future missions at the Astronaut Centre, where he and his team have developed a material that simulates lunar regolith (loose deposits covering solid rock). "We begin construction of a lunar facility later this year, using 600 tonnes of this simulant, to prepare our astronauts, to test equipment and to validate operations on the lunar surface."

Of appeal to the commercial sector is the potential range of metals and materials available at the South Pole, and their resale value. While there are some existing treaties in place over who can claim ownership of what beyond Earth, (Outer Space Treaty 1967, Mining Space Act 2015), with so many people heading towards the Moon, these rules may require reclassification.



NASA has announced its intentions to set foot on the lunar south pole by 2024, with a crew that will include the first woman on the Moon

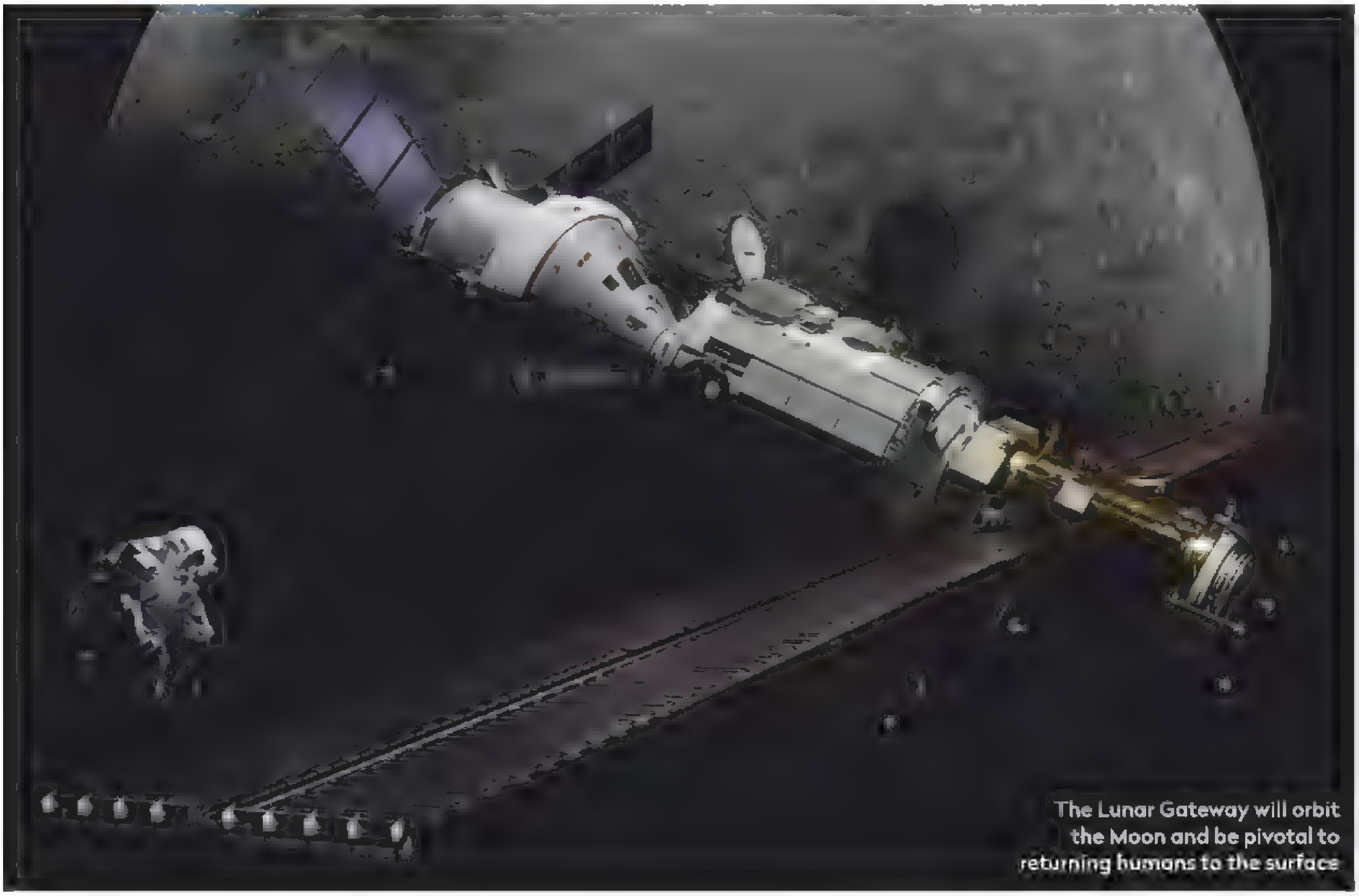
as part of a study to see how future missions could utilise the resources already found on the Moon. It is due to launch in 2024.

NASA, meanwhile, has more ambitious plans. NASA administrator Jim Bridenstine announced earlier this year its intentions to attempt to touch down at the lunar South Pole by 2024, with a crew that will include the first woman to set foot on the Moon. Named the Artemis mission, this is phase one of a much larger ambition to establish a sustainable human presence on the Moon by 2028, and then go onwards to Mars by the 2030s.

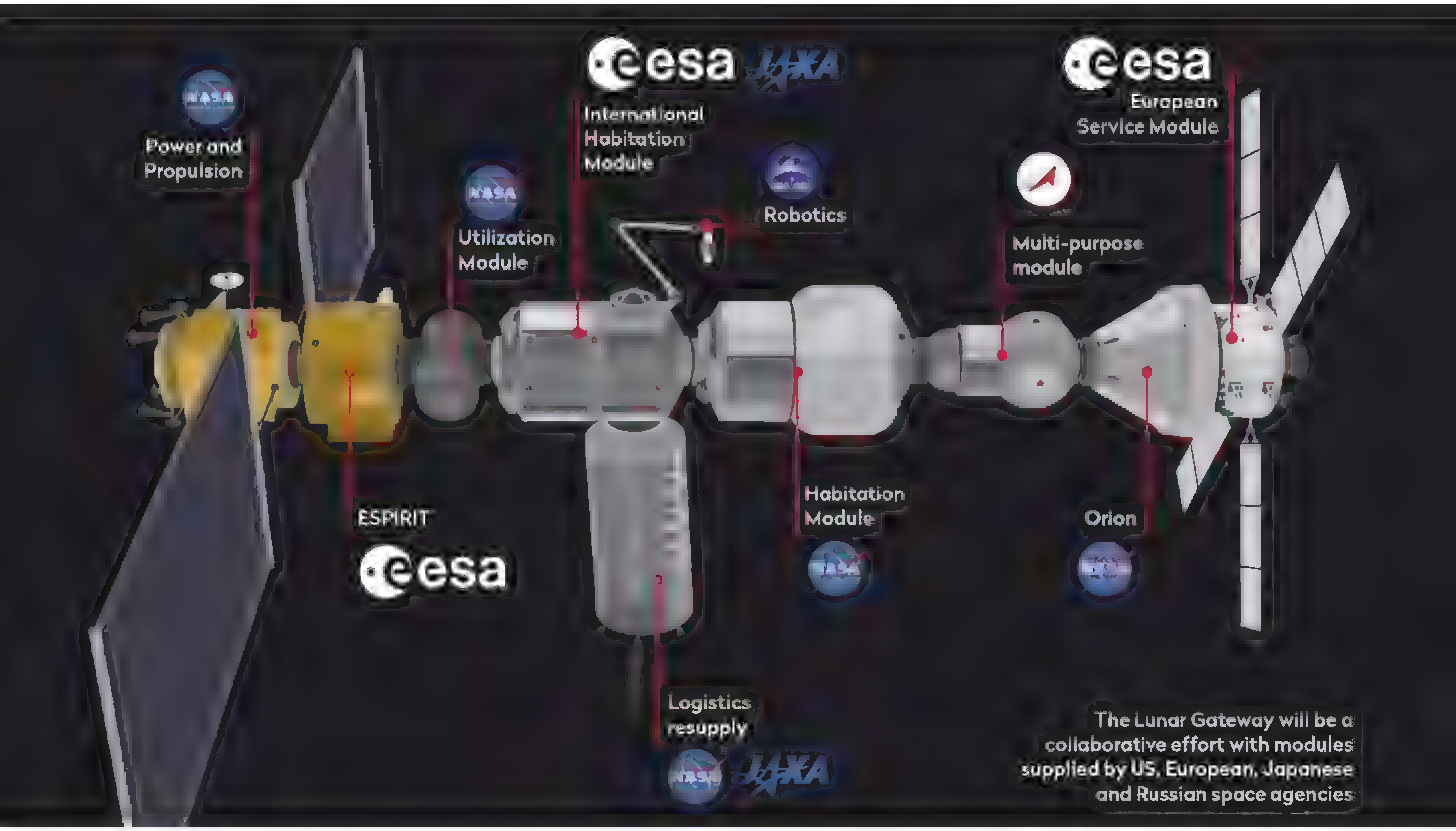
"'The most significant component of NASA's lunar aspirations is the construction of a new Moon-orbiting outpost called the Gateway," says Michael Interbartolo, one of NASA's moonshot navigators guiding their lunar plans at Johnson Space Center. "The Gateway will be a command module which once established, will continuously orbit the Moon on a near-rectilinear halo orbit (NRHO), ranging from 1,500km to 70,000km from the lunar surface."

"The Gateway will initially be constructed to complete Phase 1 of the mission – the return of humans to the Moon – and will be composed of a power and propulsion element contracted to Maxar Technologies in May 2019 and a mini-habitat element soon to be contracted. In 2024, when the SLS (Space Launch System) and Orion spacecraft are ready for launch, four astronauts will arrive at the Gateway for a 30-day mission."

After this 'first boots' phase is complete, the second phase of Gateway construction begins. And collaboration is key to its success. Building on the agreements in place for the International Space Station, ▸



The Lunar Gateway will orbit the Moon and be pivotal to returning humans to the surface



The Lunar Gateway will be a collaborative effort with modules supplied by US, European, Japanese and Russian space agencies

▸ agencies such as NASA, Roscosmos, the Canadian Space Agency, the Japanese Aerospace Exploration Agency and ESA will participate in a range of human and robotic exploration using the Gateway.

"European ministers in charge of space activities will meet in November to finalise ESA's vision for the future of Europe in space and we will be proposing to participate with NASA in the Lunar Gateway," says Didier Schmitt, the coordinator for human and robotic exploration at this ministerial meeting.

ESA hopes to provide several elements including a habitation module, advanced telecommunications propulsion systems and a science airlock system.

"As you know with space, it's all about what you can barter. By providing these modules, we would hope to be in a strong position to have an ESA astronaut on the Gateway by 2027," says Schmitt.

A spirit of collaboration

Several other ISS-partnering countries have expressed an interest in collaboration. "Canada has made an agreement to provide the robotic arm, and JAXA and Roscosmos are also in talks with Bridestine," Interbartolo confirms. It appears that this could become as international as the space station.

"Once Phase 2 is established, it is envisaged that human lunar missions will occur once a year, lasting between 30 to 90 days, depending on capabilities," says Interbartolo. "While it won't be a permanently crewed craft like the ISS, science would be robotically achieved or controlled remotely from the ground. And then, after 2028, it is hoped that after several short sortie missions to the lunar surface, we can understand better how to establish a Moon base at the South Pole.

"We can learn a lot from long-duration stays on the lunar surface, as we have no gauge on the human physiology in a partial gravity environment," he

Dr Niamh Shaw is an engineer, scientist and analogue astronaut who has participated in Mars missions in Utah, the US and Israel

"We would hope to be in a strong position to have an ESA astronaut on the Gateway by 2027" – Didier Schmitt

NASA/ESA, SPACE X, ESA/P CARRIL/SCIENCE PHOTO LIBRARY

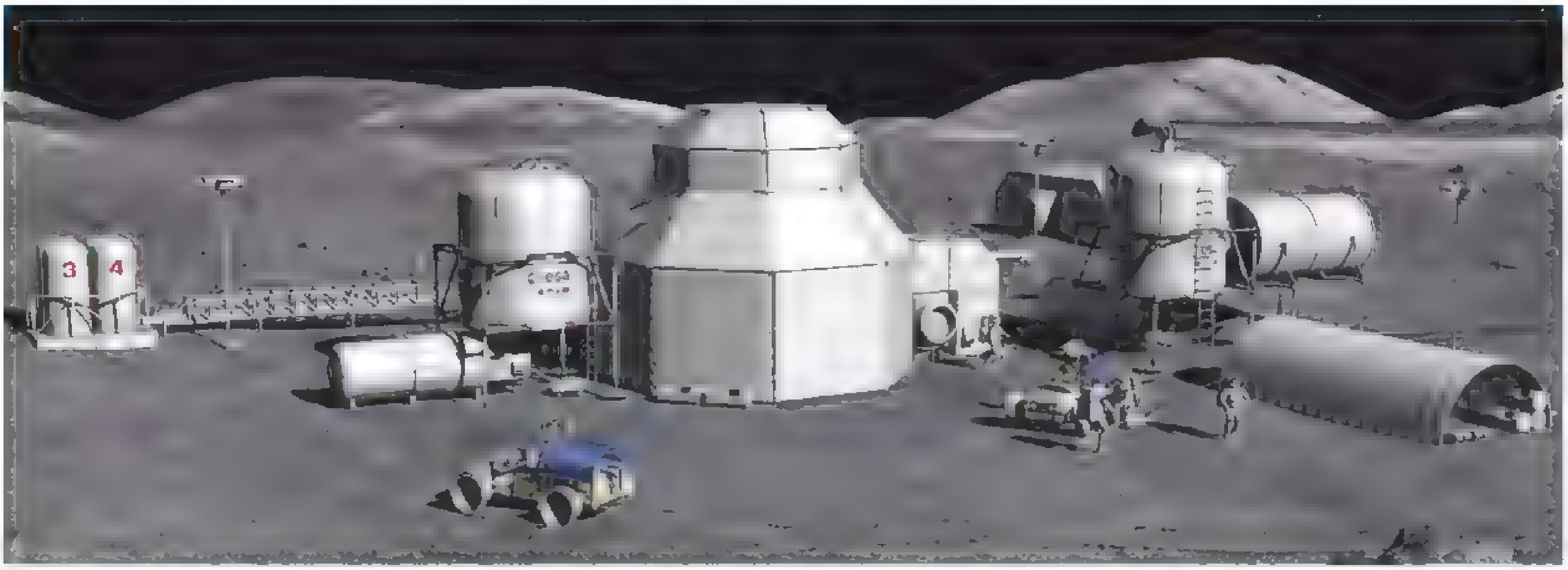
Why has there been such a long gap?

Political and technological factors have delayed our return to the Moon

Space stations and robotic science missions have been the main focus of space exploration since the Apollo missions ended in 1972. Since then, human trips to space have been limited to low Earth orbit. Without the political agenda of the Space Race, governments weren't interested in funding a space programme. And in a way, we needed to wait for the rise of commercial space, for launch costs to decrease, for new innovations to emerge such as faster prototyping, the advances in additive manufacturing, artificial intelligence and robotics – all these technologies can be adapted for applications on the lunar surface.

With the emergence of China and India and commercial space companies that weren't around 50 years ago, perhaps it forced the US and the other more prominent space agencies to rally together and realise that it was time to go back. It was time to return to the Moon together, not just for 'footprints and flags', but to live and explore. And to begin the permanent presence out into the expanse of space, and beyond the cradle of Earth.

▲ The crew module for SpaceX Demo-1 mission. The commercial sector is playing a large part in our return to the Moon



▲ Grand designs: an artist's impression of a Moon base at the lunar South Pole

explains. "We know a lot about the crews on the ISS with bone and muscle loss, but maybe the gravity on the Moon is sufficient to prevent these effects. We can learn more about the use of robotic caretakers on these long-duration missions, doing the dull stuff so that our astronauts can achieve more scientifically valid work. If we can use the Moon – just two days away – to prove these expeditionary logistics, we're in a better position to understand how all these technologies are going to work when we're 400 days away."

We are at a turning point in the history of space exploration and development, on the cusp of a revolution where new industries are being born that will use space in new ways. Fifty years ago, it was politics that drove the Space Race, perhaps this time will be driven by profit, innovation and public interest. Either way, collaboration is key, if we are to truly embrace this new dawn of exploration.

Stargazing Live returns to BBC Two in July: Brian Cox and Dara Ó Briain look at how NASA is preparing to return to the Moon, including robots designed for lunar mining and the Space Launch System. *See Radio Times for details.*

LEADERS THROUGH INNOVATION

STARLIGHT XPRESS

TRIUS Cooled USB3.0 CMOS Cameras

Introducing cooled CMOS cameras to our product portfolio.

CMOS technology is moving ahead at a fast rate. With Quantum Efficiencies (QEs) starting to rival those of traditional CCDs, along with low read-noise figures, some slightly below that of our CCD cameras, CMOS is starting to become a viable alternative.

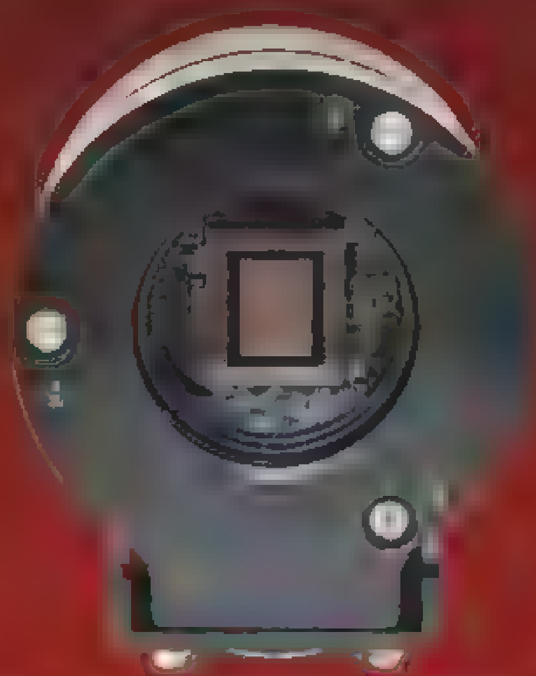
For fast planetary imaging, CMOS is now the dominant sensor, however, it does suffer from amplifier glow which is inherent in all CMOS sensors and is a problem for deep-sky imaging. Many users stack thousands of short images together to achieve a longer exposure time, and this method is useful to help reduce tracking and seeing errors, however, it limits the signal to noise ratio for each frame and is not as good as adding several long exposure frames together. In both cases, it is critical to ensure that you have good calibration frames to help with the removal of amplifier glow. It can also require a lot of processing power and disk space when manipulating hundreds or thousands of stacked images together.

It has always been virtually impossible to eliminate amplifier glow without post-processing techniques, which means manipulating the raw data before it arrives at the computer. The engineers at Starlight Xpress were not about to be beaten! After working for a few months, experimenting with various clocking routines we have developed a methodology that will allow you to take long 15 minute exposures with minimal glow, while maintaining your raw data. We call this our "No Glow Technology"; (Even Sony have asked us how we do it!)

As with all of our TRIUS range of cameras, we have incorporated a USB hub into the main camera, which offers 3 x USB 2.0 ports at the rear of the camera. Each port is capable of delivering up to 200mA, and is able to drive a Lodestar, or UltraStar for guiding and also provides ports for our USB filter wheels etc. This integration greatly reduces the number of cable trails back to the computer and gives less potential cable tangling around the mount during your imaging session.

New 3 stage Peltier cooler combinations have been designed into the CMOS TRIUS cameras, along with the Argon-filled sensor chamber for delivering good cooling to the CMOS sensors.

For further information contact us -
info@starlight-xpress.co.uk
www.sxccd.com



Product	CMOS Sensor	Mega Pixels	Sensor Size (mm)	No of Pixels/Size	Read Noise (Unity Gain) #	Size Dia/ Length	QE	Weight	Full Well Depth	Data Format
CSX-304	IMX304	12.3M	14.13 x 10.35	4096 x 3000 (3.45um x 3.45um)	3e-	75mm x 70mm	62%	1lb	>11K	12 bit
CSX-249	IMX249	2.3M	11.52 x 7.2	1920 x 1200 (6um x 6um)	3e-	75mm x 70mm	80%	1lb	>33K	12 bit
CSX-290	IMX290	2.13M	5.61x 3.175	1945 x 1097 (2.9um x 2.9um)	3e-	75mm x 70mm	80%	1lb	>15K	12 bit

 # Typical read-noise values at Unity Gain. These values are reduced to approx 1.5 e- as gain is increased.

16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

AUGUST 2019

MOONLIGHT METEORS

Essential tips for spotting and imaging the Perseid meteor shower

SATURN SHINES BRIGHT

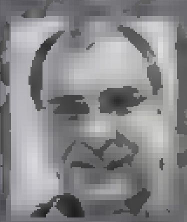
How to spot the planet's moons

MORNING MERCURY!

Wake up with the smallest planet

KEVIN KEY/SLWORKING/ISTOCK/GETTY IMAGES

About the writers



Astronomy [illegible]

Stephen [illegible]

Also on view this month...

- Discover the features of [illegible]

Red light friendly

[illegible] light under dark skies

Get the Sky Guide weekly

[illegible] www.skyatnightmagazine.com

AUGUST HIGHLIGHTS Your guide to the night sky this month

◀ First week

The start of the month is the last part of the 2019 noctilucent cloud season, perhaps offering the opportunity to catch some last minute displays.

Thursday 1

There's an opportunity to see a thin Moon this evening. You'll need a flat west-northwest horizon and clear skies to catch it. Start looking about 15 minutes after the Sun sets. The Moon's 0.8%-lit waxing crescent will have set around 30 minutes after sunset.

Tuesday ▶ 6

This month's Moon Watch target, the Apollo 11 landing area, is well presented this evening. See page 52.

This evening and tomorrow evening it's the turn of mag. +10.3 TYC6295-178-1, to appear close to Saturn.

Wednesday 7

Minor planet 16 Psyche reaches opposition shining at mag. +9.3 in the constellation of Capricornus.

◀ Tuesday 13

The annual Perseid meteor shower reaches its peak under moonlit conditions (see page 46).

Minor planet 15 Eunomia reaches opposition at mag. +8.2 in Aquarius.

Wednesday 14

Venus reaches superior conjunction, lining up with the Sun on the far side of its orbit relative to Earth. This marks the planet's transition from the morning to the evening sky. The next evening appearance is favourable for the UK.

Sunday 18

The clair obscur effect called the Twin Spires of Messier is visible this evening. The effect is connected with the crater pair Messier and Messier A. Through a scope they appear to have two spire-like shadows which seem out of keeping with the craters themselves.

Thursday 22

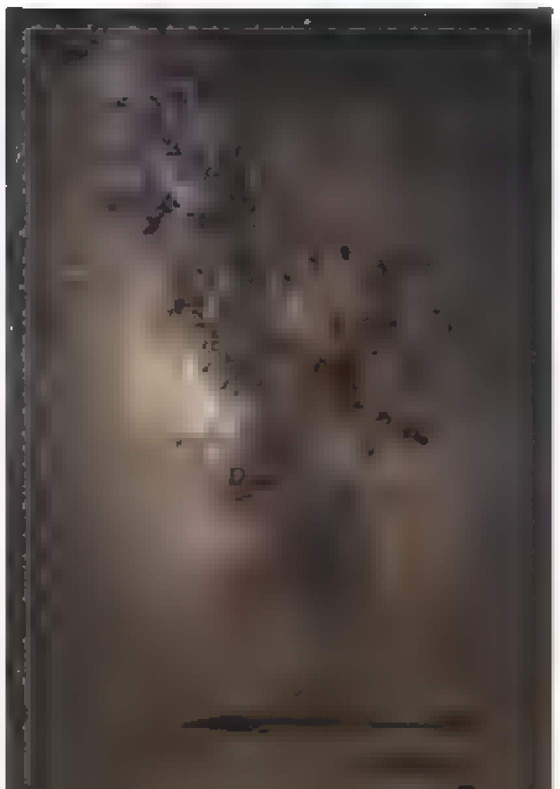
Giant Ganymede's shadow starts to cross Jupiter's disc from 20:15 BST (19:15 UT) approximately at sunset. The shadow will be more-or-less on the planet's central meridian at 21.30 BST (20:30 UT).

Sunday 25

A mag. +11.9 star, GSC6294-1471 can be seen just after emerging from behind Saturn's rings this evening. The longer you leave it the further the star will appear to move away from the planet, making it easier to spot.

Monday 26

Tonight and tomorrow night mag. –2.1 Jupiter appears to cross in front of NGC 6235, a mag. +8.9 globular cluster in Ophiuchus.



◀ Tuesday 27

The lack of Moon and lengthening darkness means this is a great time to look for the Milky Way. The bright core will be towards the south-southwest as true darkness falls, with its bright portion running through Cygnus.

PETE LAWRENCE X 7

◀ Monday 5

This evening a mag. +10.8 star, TYC6295-257-1, appears 31 arcseconds northeast of Saturn's centre. A harder 12th magnitude stars lies 57 arcseconds west-southwest of the planet at this time.

◀ Friday 9

This evening's 72%-lit waxing gibbous Moon passes 1.5° to the north of mag. –2.2 Jupiter.

Mercury reaches a greatest western elongation of 19.0°.

Sunday 11

This evening the 88%-lit waxing gibbous Moon sits 6° west of mag. +0.6 Saturn. Tomorrow evening (12 August) the now 93%-lit waxing gibbous Moon sits 6.5° to the east of the planet.

Saturday 17 ▶

Mercury is 1.2° south of the Beehive Cluster, M44. It rises east-northeast 90 minutes before the Sun.

Minor planet 39 Laetitia reaches opposition at mag. +9.1 in Capricornus. See page 53 for more details.

Saturday 24

With the Moon having moved out of the way and the nights starting to get longer, now is a great time to try this month's Deep-Sky Tour on page 56.

Saturday 31

If you found the thin Moon spotting opportunity on 1 August a bit tough, there's an easier version happening this evening when a 2%-lit waxing crescent Moon can be seen above the western horizon after sunset.

Family stargazing

There are two thin Moon spotting opportunities this month, both in the evening sky. The first is on the evening of 1 August and is likely to be very hard to see. So our recommendation is to try for the one on the evening of 31 August. This will be a 2%-lit waxing crescent Moon. Find a location with a flat western horizon. After sunset wait at least 20 minutes and then start looking for the thin crescent. Make a game of trying to spot it first. Binoculars will help as it's not easy to see with the naked eye. The Moon sets 50 minutes after sunset. www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

Perseids by MOONLIGHT

BEST TIME TO SEE: 1–15 August

Many factors affect the visibility of meteor showers. The two most important of these are radiant altitude and sky clarity. The latter is complex, being affected by weather and light pollution. The most obvious natural light polluter is the Moon and this will be present during the peak of this year's Perseid display.

The peak occurs on the night of 12-13 August when the Perseids typically deliver a maximum zenithal hourly rate (ZHR) of around 110 meteors per hour. ZHR is a misleading value that's often misquoted. It represents the number of meteors you could expect to see under perfect conditions with the radiant overhead while looking at the entire sky. In reality few of these conditions are achieved and the visual rate – that's the number of meteors you are likely to see – will be lower.

The biggest factor affecting the Perseid peak's visual rate is the naked eye limiting magnitude (NELM); the faintest star you can see with just your eyes. The normal ZHR calculation assumes a NELM of +6.5 which few of us are lucky enough to achieve.

From the centre of the UK, the Perseid radiant manages to achieve an altitude of 58°. Under perfect skies with a NELM of +6.5, a peak visual rate of 47 meteors per hour could be expected. The effect of moonlight is complicated, affecting areas of the sky closer to the Moon more than those in the opposite direction.

You can't eliminate the effect of the Moon but you can reduce it. At this time of year, the fuller phases of the Moon have low altitudes, so find a dark area away from stray artificial light and locate yourself so the Moon is hidden behind a building or fence. Look at the patch of sky with the best NELM – typically opposite the Moon. A NELM of +5.0 should deliver a peak visual rate of 14 meteors per hour, +4.5 reduces this to 10 meteors per hour while a +4.0 NELM brings the figure down to just 7 meteors per hour.

Cameras should fare better. Here, the technique is to set the camera's sensitivity high, point to a part of the sky where the Moon isn't in frame and experiment with the settings to achieve a sky which isn't over-exposed. Typically adjust your camera's ISO so that a 10–15 second exposure doesn't overexpose the shot. The lens aperture should be fairly wide open too (using a low f/number). If this can be achieved, set the camera to continuous shooting mode and repeat exposures using a remote shutter release with the shutter button locked down.

▸ A Perseid meteor photographed with light from a bright Moon in the sky

◂ Movement of the Perseid radiant during July and August. The brighter portion of the track indicates when the Moon will interfere most

ALL PICTURES: PETE LAWRENCE

Saturn's extra 'moons'

▲ Selected times when background stars will appear near Saturn. South is up in these graphics

BEST TIME TO SEE: From 23 July to mid-August

At the last count Saturn had 62 officially designated moons. This discounts the countless number of moonlets which make up the planet's rings of course. Around nine of the main moons can be seen through amateur telescopes as they continually dance around the planet. Some of these are easier to see than others.

Over time a planet moves against the background star field. Although the move may appear slow to the naked eye, through a telescope planets such as Jupiter and Saturn do manage to zip along at quite a pace. If timing and positioning are right, stars in the same brightness range as the moons can be seen nearby. Saturn is currently passing in front of the Milky Way and this part of the sky is rich with background stars.

Most of the encounters involve stars around 11th magnitude which isn't too bad a match for several of Saturn's real moons. It's worth looking on every clear night and recording the position of the moons, just in case one is a star. Highlights include a mag. +10.3 star passing from the southwest of the planet on 6 August to the east on the 7th. A mag. +11.5 star appears to approach Saturn from the west on the night of 10 August, managing to get half-an-arcminute from the planet's centre just before Saturn sets. A mag. +10.6 star appears less than an arcminute to the southwest of Saturn on the night of 14 August and 2.3 arcminutes to the east on the night of 15 August.

One of the best ways to record these random encounters is to image the Saturnian system and animate the results. The apparent movement of a background star relative to Saturn and its orbiting moons should be quite obvious. You can find out how to do this on page 76.

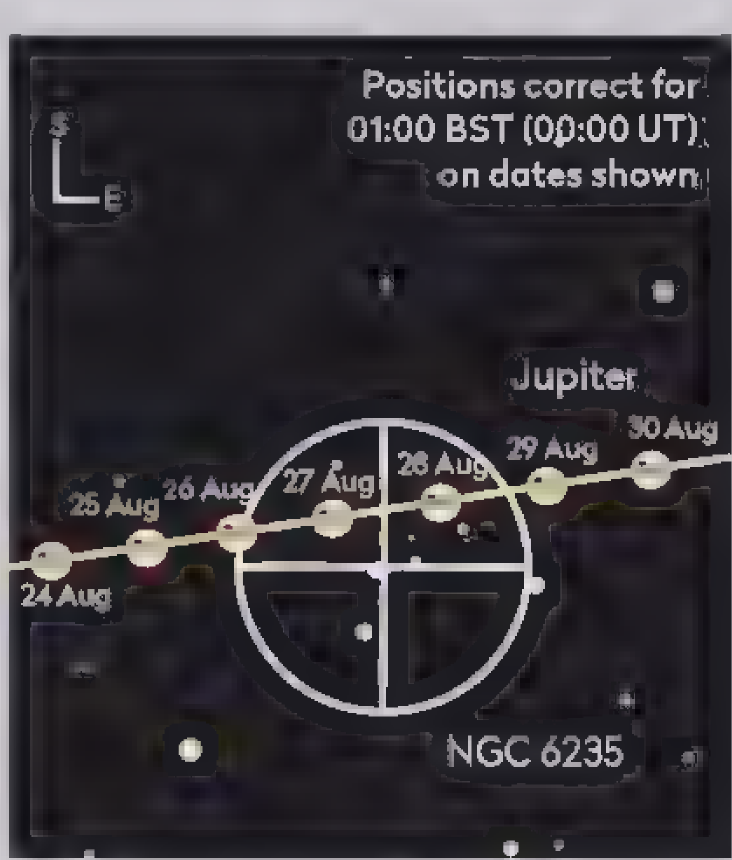
Jupiter creeps up on a cluster

BEST TIME TO SEE: 20–30 August

Not to be outdone by Saturn, Jupiter also has its fair share of background star encounters. But this month it goes one better by appearing to pass in front of the globular cluster NGC 6235. Dramatic though this sounds the brightness of mag. –2.1 Jupiter will tend to drown out the ninth magnitude globular but the rarity of the event makes it an interesting one to try and observe or image.

The best strategy will be to let Jupiter sneak up on the globular. This will give you an opportunity to view the globular without Jupiter in the field by simply placing the planet outside the eyepiece view. Start looking from around 20 August when Jupiter will be approaching the globular from the west. There will be a bit of a balancing act with the Moon on this date but the good news is that things will only get better in this respect.

The actual encounter takes place between 26 and 29 August. Jupiter appears to pass just to the south of NGC 6235's core. Despite the globular having a decent apparent size of 5 arcminutes, much of this will be very faint and it's probably only the inner 1-2 arcminutes which encompasses the core that you'll see.



▲ Look to the west as Jupiter approaches the globular cluster NGC 6235

THE PLANETS Our celestial neighbourhood in August

Appearance of Mercury relative to the horizon at 05:20 BST (04:20 UT) during August, as viewed from the centre of the UK

PICK OF THE MONTH

Mercury

Best time to see:
9 August, 1 hour before sunrise
Altitude: 5° (low)
Location: Gemini
Direction: East-northeast
Features: Phase, mottled surface features through larger telescopes or via imaging
Recommended equipment:
A 75mm or larger telescope

Although Mercury isn't particularly easy to see at the start of the month, its position does improve as time passes. By the time it reaches greatest western elongation on 9 August, it rises approximately 100 minutes before the Sun.

An elongation is the point in an inferior planet's orbit when from Earth the planet appears at either the eastern or western extremity of its orbit (an inferior planet is one with an orbit smaller than Earth).

On 1 August, Mercury will be approaching greatest western elongation. Through a scope it will appear 9 arcseconds across and present a 13%-lit crescent. It rises one hour before the Sun on 1 August and shines at mag. +2.0.

It brightens quite rapidly as it approaches greatest western elongation and this, along with its increased apparent separation from the Sun, will make it much easier to see. On 9 August it shines at mag. +0.3 and through a scope appears 37%-lit and 7 arcseconds across.

▲ Mercury will get brighter and easier to see in the morning sky

Although it appears to get closer to the Sun after this date, its appearance in the morning sky actually improves. This is due to it becoming brighter and moving to the north of the ecliptic. On 23 August Mercury appears at mag. –1.2, setting 70 minutes after the Sun. Later in the month, despite being bright, its visibility will become hampered by its proximity to the Sun.

Mercury's appearance through a scope tends to be compromised when it's in either the evening or morning twilight because it's always quite low. Despite this its phase is quite evident and can be seen with a 75mm instrument at around 100x power. Larger instruments may be able to reveal surface shadings if the seeing is good.

PETE LAWRENCE X 3

The planets in August

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope

Mars

Best time to see: 1 August, 20 minutes after sunset
Altitude: 0.75° (extremely low)
Location: Leo
Direction: West-northwest
Mars is all but lost from view this month. There is a thin Moon spotting opportunity on 1 August when it may be possible to see a less than 1%-lit waxing crescent in clear skies. If you look for the Moon, mag. +1.8 Mars is located 0.8° south-southeast of its crescent shortly after sunset; that's below and slightly left as seen from the UK. On 24 August, Venus appears to pass Mars by 0.3°, although the pair will only be 3° from the Sun.

Jupiter

Best time to see: 1 August, 22:30 BST (21:30 UT)
Altitude: 13.5°
Location: Ophiuchus
Direction: South-southwest
Jupiter is showing a low aspect, a situation which will persist for another couple of years before it starts to climb to a more northern part of the ecliptic. A side effect of its low altitude is that its period of observation is short, Jupiter appearing in dark skies for less than four hours. A 72%-lit waxing gibbous Moon lies 1.5° north of mag. –2.2 Jupiter on the evening of 9 August. On the evenings of 26 and 27 August Jupiter appears to pass in front of the globular cluster NGC 6235 – see page 47.

Saturn

Best time to see: 1 August, 23:40 BST (22:40 UT)
Altitude: 15°
Location: Sagittarius
Direction: South
Mag. +0.5 Saturn is in Sagittarius moving slowly towards the west at the start of August, a movement which positions it under the bowl of the spoon in the Teaspoon asterism, which itself lies to the northeast of the Teapot asterism. In the UK you'll see a bright 88%-lit waxing gibbous Moon sit to the west of Saturn on 11 August and to its right on 12 August. Saturn appears at its highest point in the sky, due south, in relative darkness all month long. It's tilted over by 25° so that its northern pole is closer to Earth.

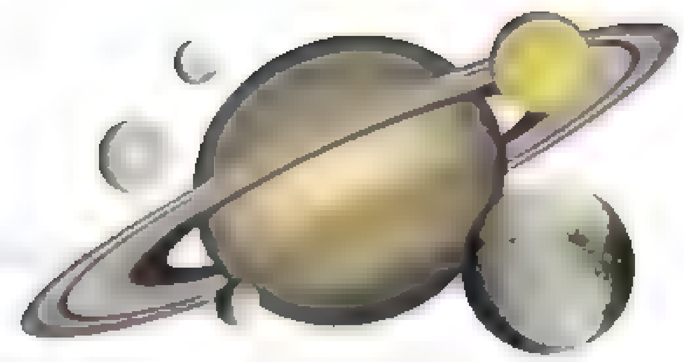
Uranus

Best time to see: 31 August, 03:45 BST (02:45 UT)
Altitude: 48°
Location: Aries
Direction: South-southeast
As the nights begin to draw in, so the observing situation for mag. +5.7 Uranus improves. At the end of the month, Uranus manages to reach its highest point in the sky, due south, in reasonable darkness. The planet has drifted east out of Pisces and into neighbouring Aries. Its peak altitude as seen from the centre of the UK is 50°, making distant Uranus the best placed planet currently on offer.

Neptune

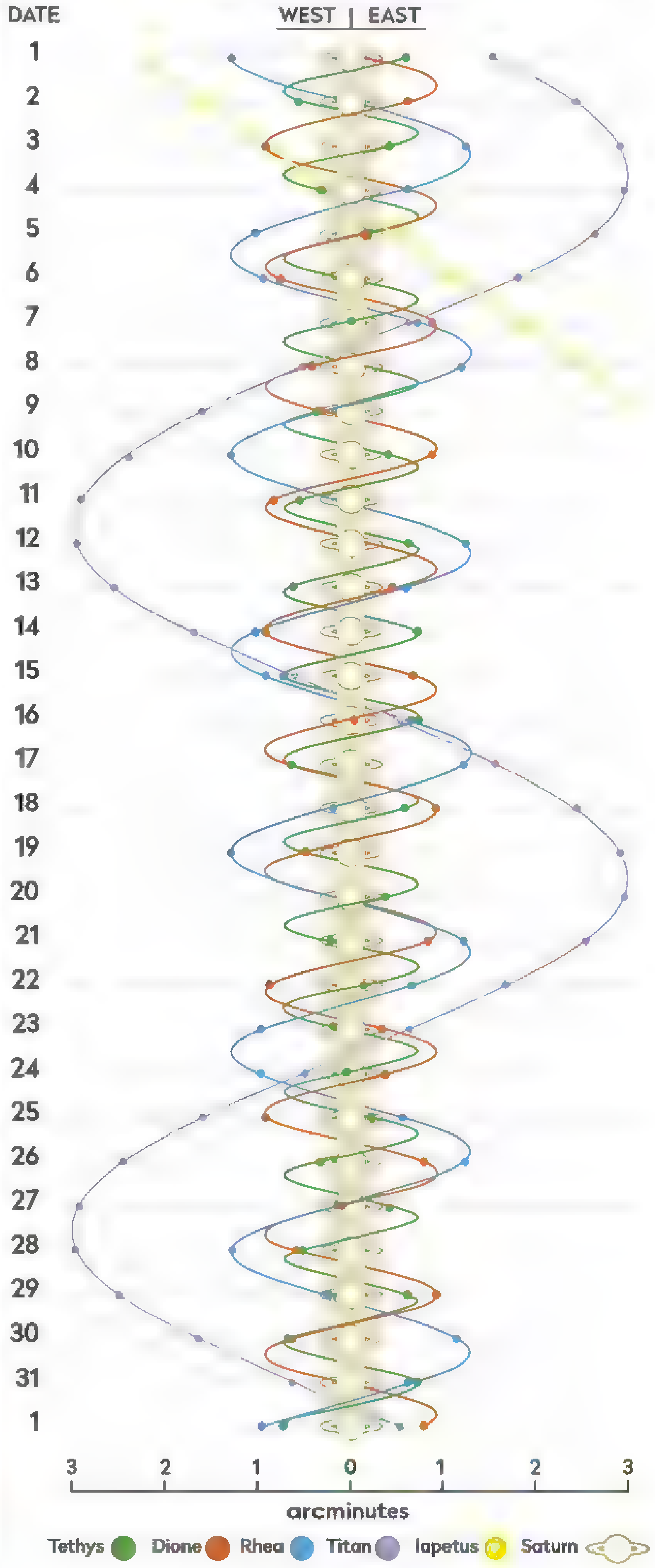
Best time to see: 31 August, 01:45 BST (00:45 UT)
Altitude: 31°
Location: Aquarius
Direction: South
Mag. +7.8 Neptune doesn't make it to its highest position due south at the start of August but the lengthening nights and its drift westward means that it achieves this feat from around mid-month onwards. Binoculars are required to spot Neptune, but a scope will show its distinct blue colour. Neptune is in Aquarius, situated close to the mag. +4.2 star Phi Aquarii.

NOT VISIBLE THIS MONTH:
VENUS



SATURN'S MOONS: AUGUST

Using a small scope you can spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – AUGUST

Explore the celestial sphere with our Northern Hemisphere all-sky chart

CHART PETE LAWRENCE

When to use this chart

1 August at 01:00 BST
15 August at 00:00 BST
31 August at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in August*

Date	Sunrise	Sunset
1 Aug 2019	05:25 BST	21:06 BST
11 Aug 2019	05:42 BST	20:47 BST
21 Aug 2019	05:59 BST	20:26 BST
31 Aug 2019	06:17 BST	20:03 BST

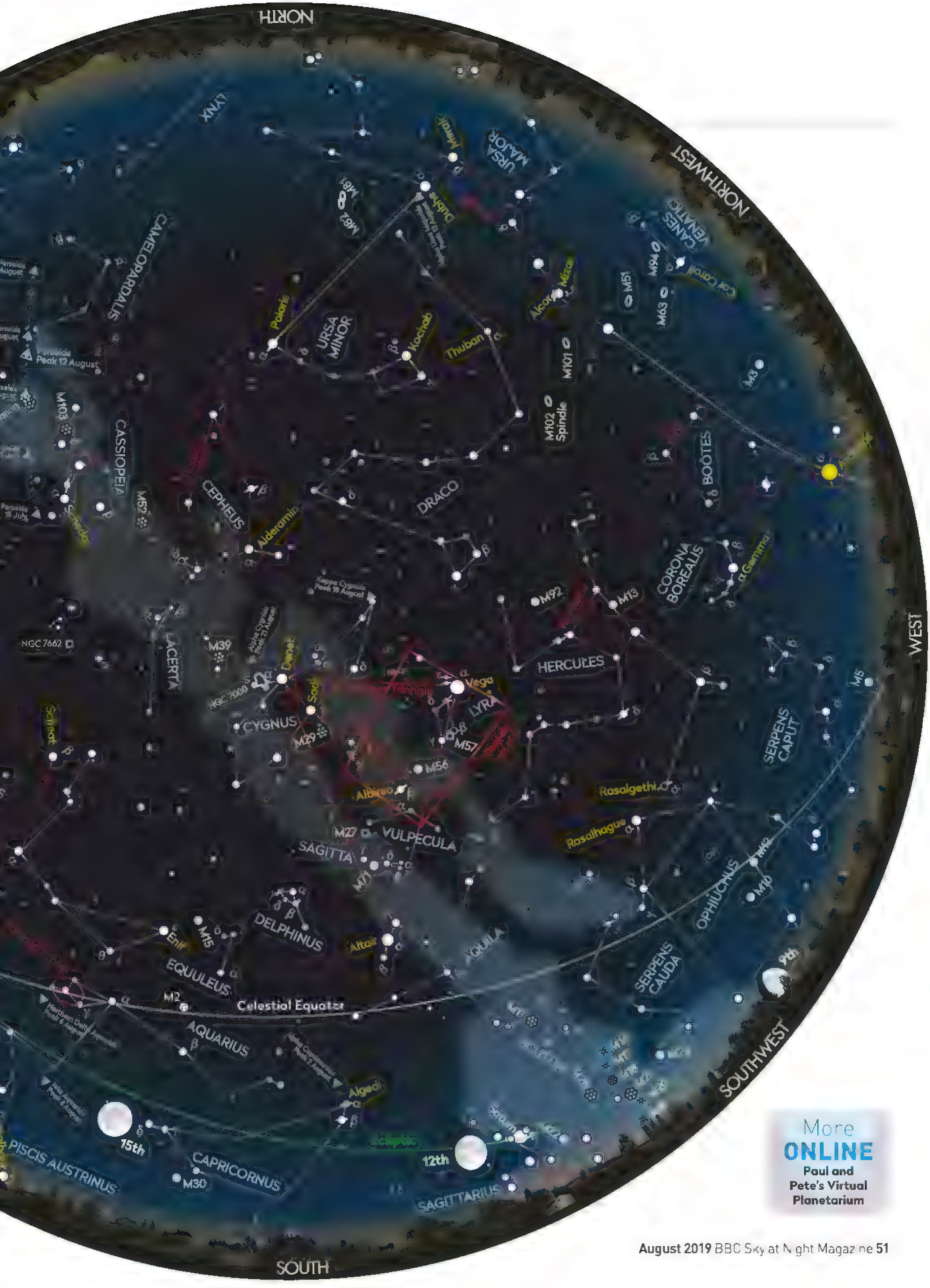
Moonrise in August*

Moonrise times

1 Aug 2019, 05:27 BST	17 Aug 2019, 21:43 BST
5 Aug 2019, 11:12 BST	21 Aug 2019, 22:48 BST
9 Aug 2019, 16:26 BST	25 Aug 2019, 00:06 BST
13 Aug 2019, 20:05 BST	29 Aug 2019, 04:19 BST

*Times correct for the centre of the UK

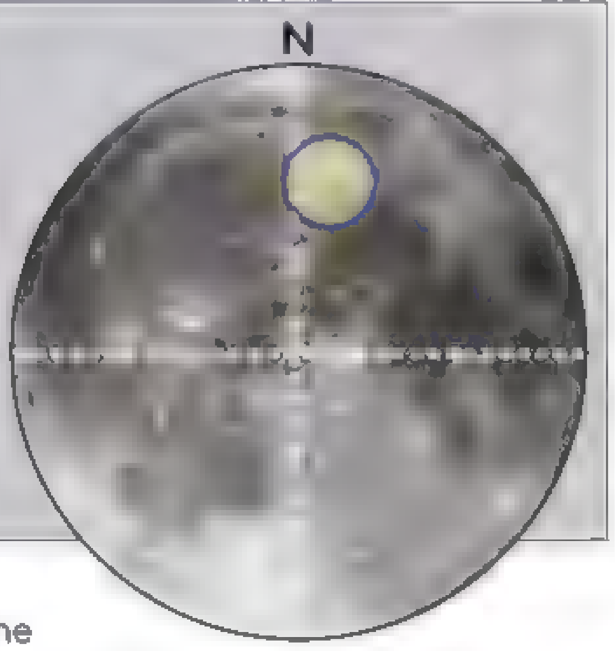
Lunar phases in August



More
ONLINE
Paul and Pete's Virtual Planetarium

Apollo 11 landing site

Type: Region on the Moon
Size: 300kmx300km (area described)
Longitude/latitude: 23.5° E, 0.7° N
Age: 50 years
Best time to see: Five days after new Moon (6 August) and four days after full Moon (20-21 August)
Minimum equipment: 200mm telescope



A commonly asked question regarding the Apollo landing sites is whether they can be seen from Earth. Unfortunately the landing craft are too small to be seen by even the largest Earth-based telescopes. A large amateur telescope may typically resolve features as small as 600-700 metres across. A test shot taken by Yepun, one of the four 8.2m telescopes located at Paranal in Chile, part of the Very Large Telescope (VLT) facility, resolved features as small as 130m across, close to the telescope's resolving limit. Both figures are a long way off the 4.2m width of the body of the Apollo lunar module's descent stage, which was left on the surface.

Sadly, in order to see the Apollo 11 base, you'd currently need to have a spacecraft in lunar orbit or actually go to the site. To date, the Lunar Reconnaissance Orbiter (LRO) has successfully returned images of all the Apollo sites, showing the descent stages, equipment, walking trails and, where applicable, tracks made by the lunar rovers.

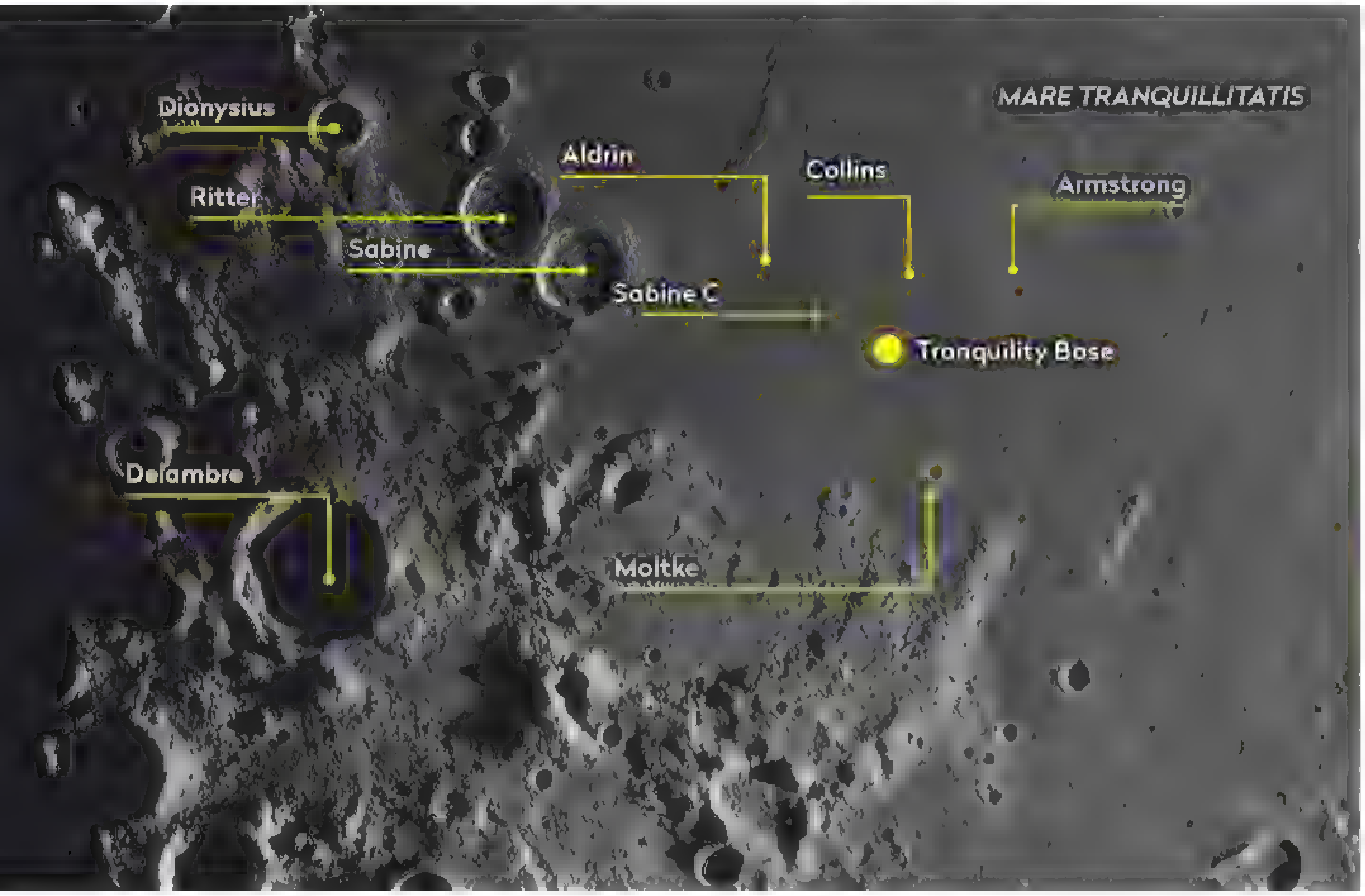
Despite not being able to see the spacecraft themselves, it is still possible to explore the landing sites

Despite not being able to see the spacecraft themselves, it is still possible to explore the landing sites and get a feel for where they are located on the lunar surface. Apollo 11's Tranquillity Base is, as its name suggests, in the Sea of Tranquillity, **Mare Tranquillitatis**. The dark lava of this 700km diameter sea is easily visible to the naked eye, but a telescope is required to explore the vicinity of the landing site. In the southwest 'corner' of the mare is a pair of similarly sized craters, 31km **Ritter** and 30km **Sabine**. Both craters have a remarkably similar appearance showing relatively flat floors and steep, well defined rims.

Imagine a line from the centre of Ritter to the west, through the centre of Sabine. It hits the boundary of Tranquillitatis at a point where the highland edge appears scalloped out around a smaller crater on the mare surface, 7km **Moltke**. This is a bowl-shaped depression with a bright ejecta collar which really helps it stand out against its dark lava surroundings.

Look at the scalloped mare boundary feature and take note of its east-west dimension; it's about 60km across. Return to Moltke and head north by a little over this distance, veering slightly to the east as you go. Here you'll find 5km **Armstrong**, named after the first man to step foot on the Moon, Neil Armstrong. The other crew members, Buzz Aldrin and Michael Collins also have craters in the region and these can be located by drawing a line between Armstrong and the centre of Sabine. From Armstrong **Collins** is a 3km crater 38km along this line. Keep going for another 50km and you'll arrive at 3km **Aldrin**.

Just south of the mid-point between Aldrin and Collins is a triangle of similar sized depressions, 3km **Sabine C** being the northernmost of the three. A line drawn between the lower two, running west to east and extended for virtually the same distance again, will have you looking directly at the historical site of Tranquillity Base, where the Apollo 11 lunar module Eagle landed at 21:17 BST (20:17 UT) on 20 July 1969.



▼ In Mare Tranquillitatis three craters are named after Apollo 11's crew – Aldrin, Armstrong and Collins

PETE LAWRENCE X 5

COMETS AND ASTEROIDS

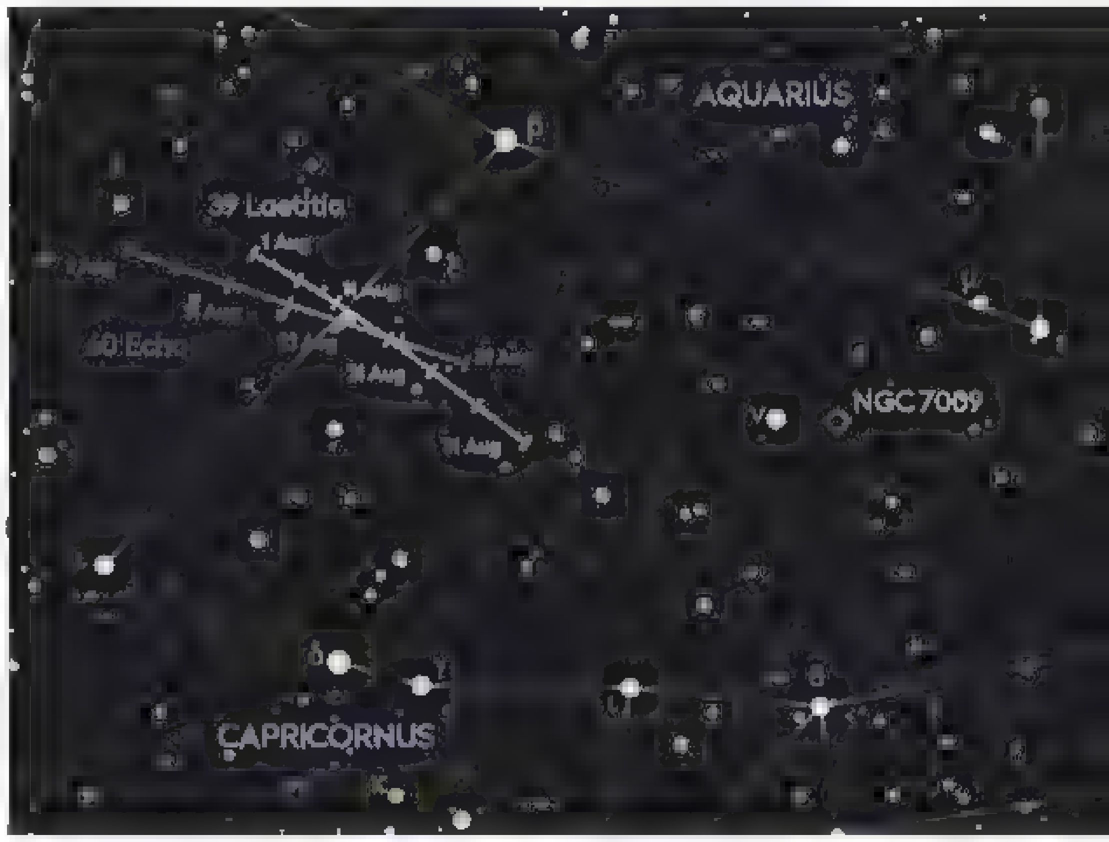
The tracks of asteroids 39 Laetitia and 60 Echo appear to cross

Much of the information about minor planet 39 Laetitia has been gathered from old-school observation techniques. Its brightness was monitored carefully for several years between 1968 and 1974 and this information was used to produce a detailed light curve for the object. From this, information about its shape and rate of rotation could be determined; it turns once on its axis every 5.1 hours.

Asteroids appear tiny as seen from Earth but if we're lucky, they can pass between us and a distant star, producing an event called an occultation. The tiny apparent size of the asteroid means that the event is typically only visible over a defined track across the surface of Earth. Accurate timing of the occultation from different locations is an invaluable way for refining the profile of an asteroid.

When these 'occultation chords' are combined, they give us an enticing hint at the asteroid's shape. This is what happened on 21 March 1998, the observations made at that time telling us that Laetitia has an ellipsoidal cross-section measuring 219x142km. A more detailed photometric study between 2006 and 2008 produced a light curve that suggests Laetitia may have a more complex structure, possibly even hinting at it being a binary asteroid.

39 Laetitia is a main belt asteroid which varies in brightness between mag. +9.0 and +12.2. It reaches opposition on 17 August when it can be found in northern Capricornus. The object starts the month off in Aquarius, slipping across the border into Capricornus on 7 August. Its magnitude doesn't vary greatly throughout the month starting at +9.5 on 1 August and rising to a favourable opposition magnitude of +9.1 on 17 August, before dimming to +9.4 by the end of the month. Laetitia will be joined by asteroid 60 Echo this month, the tracks of both bodies appearing to cross. Echo will be dimmer, rising from mag. +12 on 1 August, to +11.6 on 18 August before dimming back to +11.8 by 31 August.



▲ In August 39 Laetitia is joined in the constellation of Capricornus by 60 Echo

STAR OF THE MONTH

Mirphak, a supergiant in its later stages

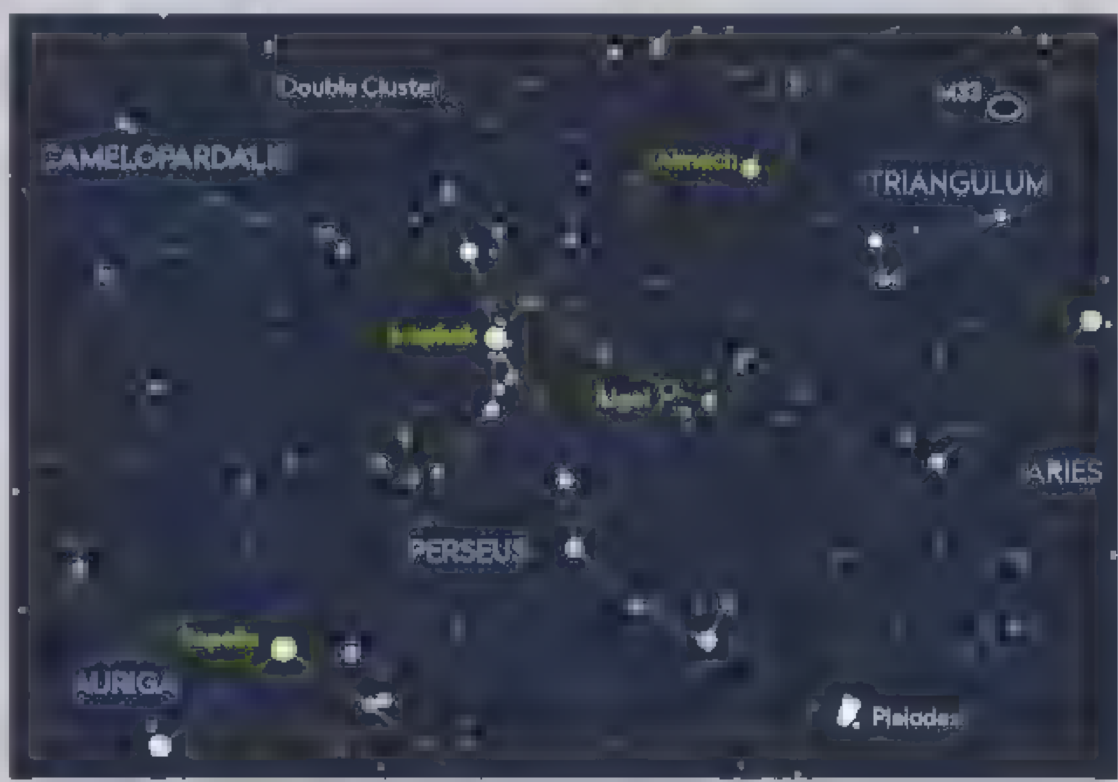
The most striking thing about Mirphak (Alpha α Persei) when you look at it through binoculars, is the small semi-circular pattern of stars that appears to nestle around it. There is a connection here as many of these stars belong to a cluster known as the Alpha Persei Cluster or Melotte 20.

The constellation of Perseus is an awkward shape to describe while standing out under the stars. It represents the Greek Hero, Perseus, but trying to place stars and patterns within the constellation to match up with a hero can be challenging. In translation Mirphak means elbow but this relates to a larger meaning where it is referred to as 'the elbow of the Pleiades'.

To the naked eye Mirphak appears as a mag. +1.8 star, slightly off-white in colour. Its spectral classification is F5 Ib, the 'Ib' indicating that it's classed as a less luminous supergiant, basically one that's moving into the later stages of evolution. Only 30-50 million years ago Mirphak would have been a hot blue B-type star.

Mirphak sits at a distance of 510 lightyears and has a mass equivalent to 8.5 Suns. Its evolutionary stage means that its size is considerably larger than this mass would otherwise suggest, the star having expanded to an estimated 60x the Sun's diameter. It shines with the luminosity of 5,000 Suns and has a photospheric or surface temperature of around 6,350 K (the Sun's is 5,778 K).

Mirphak lies on the warm edge of a pulsating star class known as Cepheid variables.



▲ Mirphak appears off-white when viewed with the naked eye

BINOCULAR TOUR With Stephen Tonkin

Curiosities include double-star Albireo, dark nebula Barnard's E and enigmatic M71

1 The Dumbbell Nebula

10x 50 We begin this month's tour with the easiest planetary nebula for binoculars. Identify Gamma (γ) Sagittae and pan a little over 3° in the direction of 15 Vulpeculae where, even in suburban skies, you will find a minuscule glowing cloud. This object, 1,360 lightyears distant, is the Dumbbell Nebula. Initially it will appear rectangular but with patience you should discern the slight narrowing in the middle that gives it its common name. ☐ **SEEN IT**

2 Albireo

10x 50 Albireo (Beta (β) Cygni) marks the Swan's eye. This double star has a separation of 34 arcseconds, a good test for 10x magnification. Once you have split it, notice the contrast between the golden mag. +3.1 primary and the azure mag. +5.0 secondary. Albireo was recently shown to be an optical double, ie, a line-of-sight coincidence. ☐ **SEEN IT**

3 The Ring Nebula

15x 70 This month's challenge is another planetary nebula. The mag. +9.5 Ring Nebula, M57, lies almost midway between Sheliak (Beta (β) Lyrae) and Sulafat (Gamma (γ) Lyrae), which makes it easy to locate, but it's less easy to identify. At 15x, it is tiny and will appear as a defocused star; so don't expect to see it as a ring. M57 is about 2,300 lightyears away, and has a diameter of 1 lightyear. ☐ **SEEN IT**

4 The Coathanger

10x 50 We now head southeast to a popular star party piece, also known as Collinder 399, Brocci's Cluster and Al-Sufi's Cluster, which lies 8° south of Albireo. It lies in a darker part of the Milky Way, so even small binoculars will reveal the 10 brightest stars that give this asterism (it is not a true cluster) its common name. It was first recorded by the Persian astronomer Abd al-Rahman al-Sufi in his AD 964 *Book of Fixed Stars*. ☐ **SEEN IT**

5 M71

15x 70 After decades of dispute as to whether this object is a dense open cluster or a sparse globular cluster, the consensus is now that it is the latter. You'll find it south of the mid-point of a line joining Delta (δ) and Gamma (γ) Sagittae. At mag. +8.2 it's quite faint, but 15x magnification should reveal that it is not a star, even with direct vision, and averted vision should confirm this. ☐ **SEEN IT**

6 Barnard's E

10x 50 One of the easiest dark nebulae you'll find is 1° west of Tarazed (Gamma (γ) Aquilae). It's a pair of nebulae, B142 and B143, and is easy to identify because of the rich starfield against which they lie. You'll need a dark, transparent sky to catch these agglomerations of gas and dust. They appear either as an uppercase 'E' or an underlined 'C', depending on sky clarity. ☐

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

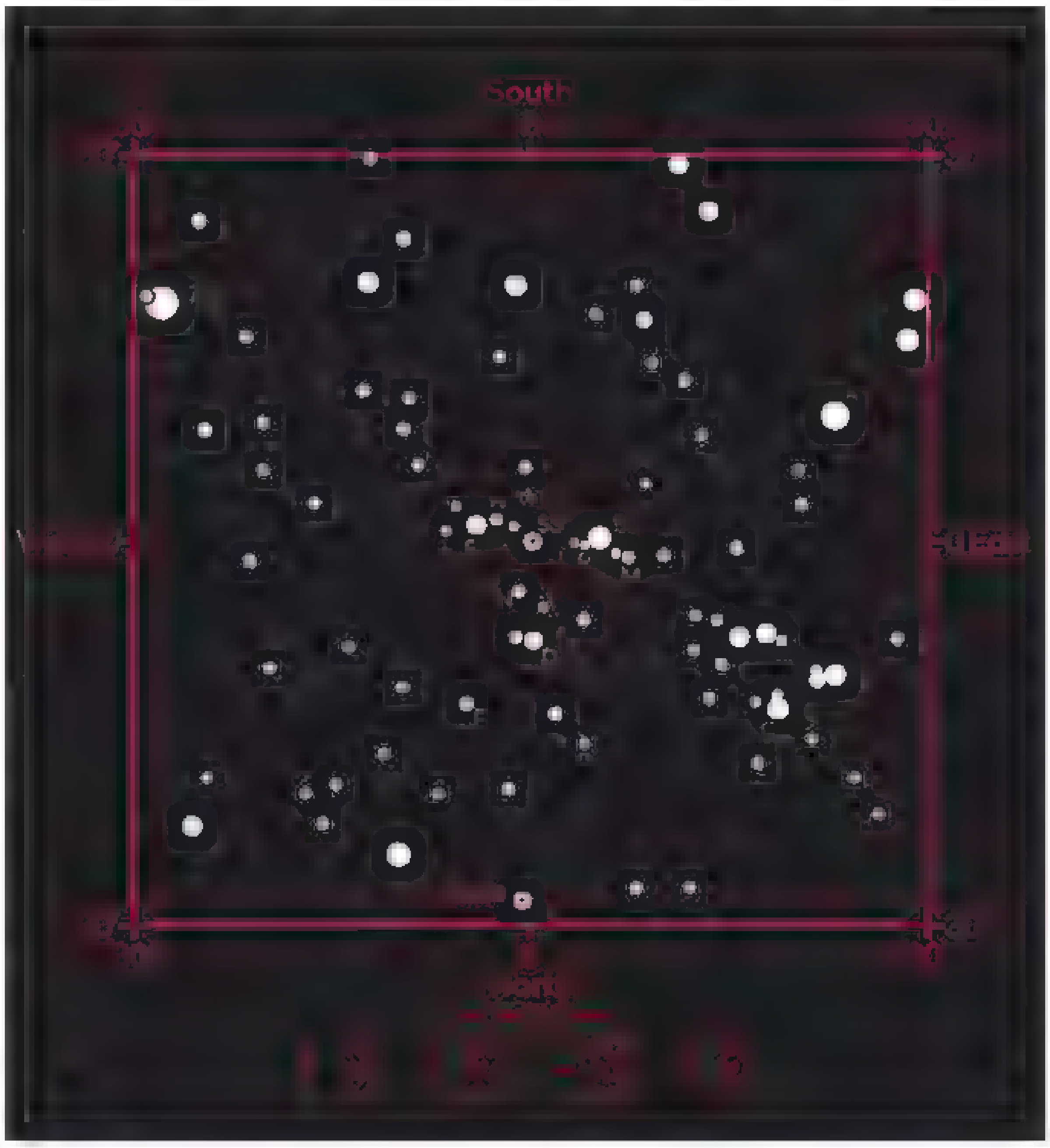
THE SKY GUIDE CHALLENGE

Get into variable star observing and discover SS-Cygni in the constellation of Cygnus

▲ A wide field view shows how to find variable star SS-Cygni, near star 75 Cygni, with the rich star fields of the Milky Way in the background. The red square area is enlarged below

SS-Cygni is a variable star in the constellation of Cygnus. It's the prototype of a sub-class of dwarf novae: the U Geminorum class of cataclysmic variables. SS-Cygni type variables exhibit a 2-6 magnitude rise in brightness for a short period of 1-2 days. In the case of SS-Cygni, it appears to brighten from 12th magnitude to around eighth magnitude every 7-8 weeks. It remains at this brightness for 1-2 days before gradually dimming back to 12th magnitude once again over the course of a week or so.

The system consists of two stars in close mutual orbit, a red dwarf and a white dwarf. The separation between the stars is believed to be small at just 160,934km or 0.001 AU. Matter transferred from the red dwarf towards the white dwarf results in a luminosity increase in an accretion disc orbiting the white dwarf. Monitoring the eruption is very satisfying and a great way to get into variable star observing if you have never attempted it before.



▲ A telescopic view (south up) showing the star field around SS-Cygni and selected comparison stars of fixed magnitude

SS-Cygni has a number of characteristics which make it an ideal target for observation. It has a relatively high declination of +43.6°, placing it high up in the sky for study from the UK. In addition it sits against a star-rich portion of the Milky Way, which means that there are plenty of surrounding stars of fixed magnitude suitable for comparison purposes. One of the best ways to estimate the brightness of a variable star is to compare it to that of surrounding stars. There are various ways to do this, including picking one brighter and one fainter for comparison. It's then possible to mentally subdivide the brightness difference between them into say 10 divisions and estimate where the variable sits on that scale.

The first task is to locate the field containing SS Cygni. Our recommendation would be to draw an imaginary line from mag. +5.2 71 Cygni through mag. +4.0 Rho (ρ) Cygni, extending it for twice the distance again. This will put you in the right area. Another guide is the mag. +5.1 Star 75 Cygni. SS-Cygni lies 37 arcminutes to the east-northeast of this star.

The next step is to look at the field through the eyepiece of your telescope and attempt to match star patterns with the charts provided. There are two bright stars relatively close by which provide upper range anchors; a mag. +8.6 one quite close to SS-Cygni and a mag. +7.7 one a bit further away. As you'd expect, there are no shortage of lower-range comparison stars in this part of the sky.

SS-Cygni is a great target for visual observations but can also be recorded photographically. With similar settings, an image of the star at minimum brightness compared to an image at maximum brightness shows the dramatic change this system can exhibit.

DEEP-SKY TOUR

From the double life of Epsilon Lyrae, to the famous Ring Nebula and 'fuzz-ball' cluster M56

1 Epsilon Lyrae

Epsilon Lyrae can be found marking the northeast vertice of an equilateral triangle with Vega (Alpha (α) Lyrae) and Zeta (ζ) Lyrae. Good eyes will reveal it to be double, but you'll need a 150mm scope with good optics to reveal its hidden secret. Both of the components for the naked eye double are tight doubles again. The Epsilon-1 pair to the north is formed by mag. +5.1 and +6.0 components separated by 2.8 arcseconds. Epsilon-2 comprises mag. +5.1 and +5.4 components separated by 2.2 arcseconds. All four stars in this system are gravitationally linked, the Epsilon-1 pair orbiting one another every 1,800 years, while the Epsilon-2 pair mutually orbit each other every 724 years. The nature of the system has led to it becoming known as the Double-Double for obvious reasons. It lies 161 lightyears from the Sun. ☐ **SEEN IT**

▲ **To see the 'hole' in the Ring Nebula, M57 you'll need a scope over 150mm**

2 Stephenson 1

The main part of Lyra has a distinctive shape. From brilliant Vega a squashed diamond of fainter stars hangs southeast. The top of the diamond is marked by Zeta Lyrae and Delta (δ) Lyra which marks the location of the open cluster Stephenson 1. The cluster is also known as the Delta Lyrae Cluster. Delta is a double star with orange Delta-2 being the star associated with the cluster. It's relatively sparse and easy to overlook, but thanks to Delta-2's colour contrast with blue Delta-1 it's a great part of the sky to image. It is classed as an open cluster. ☐ **SEEN IT**

3 Minkowski 1-64

Lyra is famous for planetary nebula M57 which we'll meet shortly, but this is not the only planetary nebula on offer. Minkowski 1-64 is a 13th magnitude planetary which, like M57, appears as a ring, here 17 arcseconds across. If you imagine a line joining the midpoints of both long sides of the squashed diamond mentioned earlier, Minkowski 1-64 lies a quarter the way from the western mid-point along that line. A 200mm scope will show it as a round grey disc of uniform brightness. A 300mm or larger scope will be required to reveal the ring-nature of the planetary. A mag. +13.9 star sits on the northern edge of the ring. ☐ **SEEN IT**

4 M57

On to the main event the Ring Nebula, M57. This is easy to find sitting between the two lower stars of the squashed diamond, Sheliak (Beta (β) Lyrae) and Sulafat (Gamma (γ) Lyrae). Its position is slightly south of the line joining these stars slightly towards Sheliak. A 75mm scope will show it but a 150mm or larger is required to show the 'hole' in the centre of M57's oval-shaped glow. The darkened hole is what gives the nebula its ring-like appearance. The central star, the object which blew off its outer layers to form the ring, is dim, around mag. +14.7 and will require a 375mm or larger instrument to see clearly. ☐ **SEEN IT**

5 NGC 6765

Our next target is a planetary nebula too. Listed as a mag. +12.9 object 38 arcseconds across, NGC 6765 is quite challenging and unusual. To visualise where it is in the sky, it's located virtually midway between Albireo (Beta (β) Cygni) and Sheliak. A large scope and dark skies are needed and the use of an OIII filter will make the task easier. It appears to have a central bar with two extensions of unequal brightness. The rounder glow of the main planetary has a definite elongation to it at position angle 30°. ☐ **SEEN IT**

6 M56

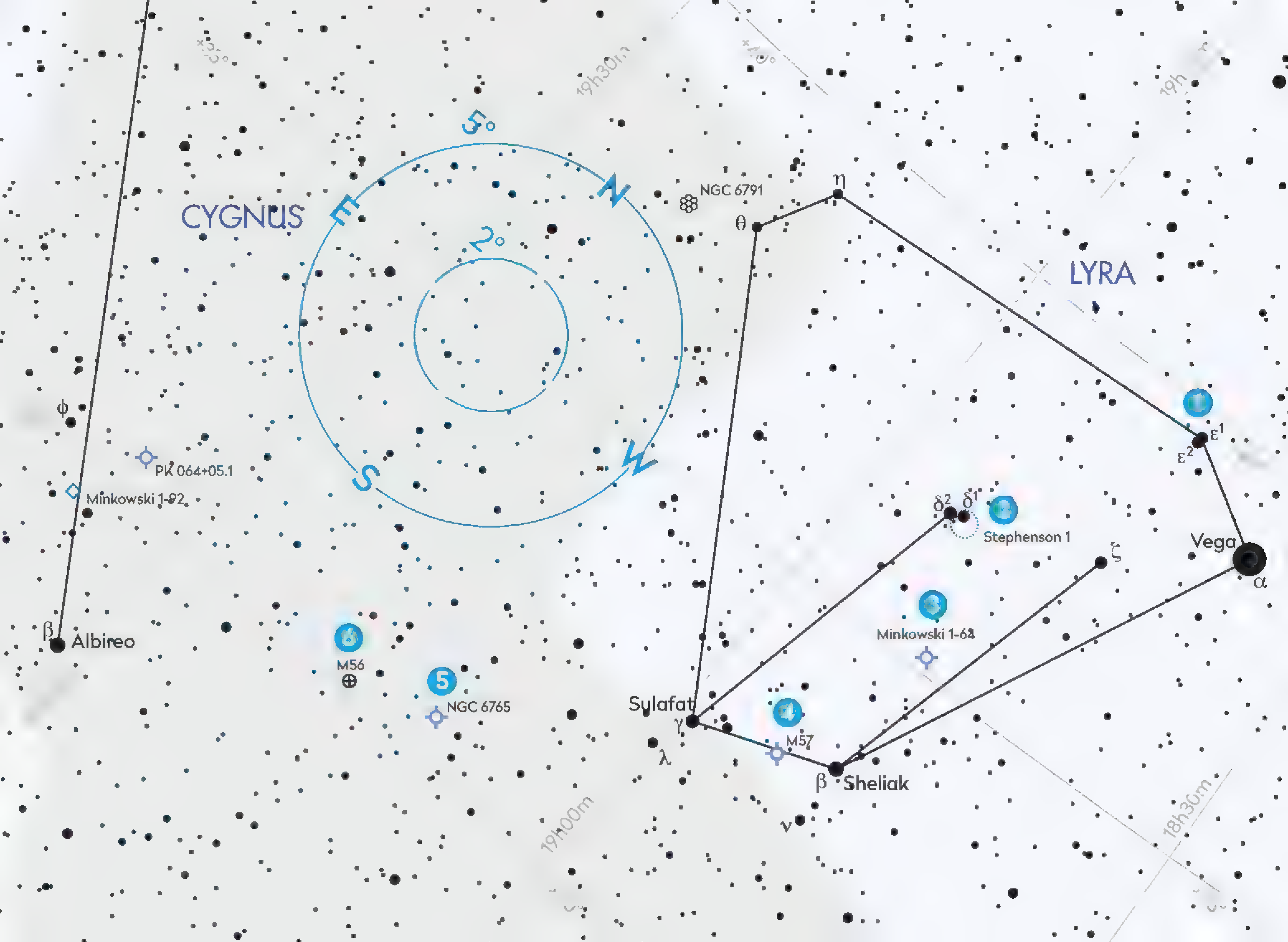
Last is globular cluster M56. This sits at the mid-point between Sulafat and Albireo, 1.2° east-southeast of NGC 6765. At mag. +8.3 this shouldn't give any real identification issues. Its full apparent diameter is 8.8 arcminutes, although expect to see something around 5 arcminutes. We'd recommend a 100mm or larger scope for M56. It's best described as a fuzz ball which brightens towards the middle. It can be challenging to see well unless your skies are good and dark. Larger apertures shouldn't have much problem resolving the member stars. M56 is 32,900 lightyears from our Sun. ☐ **SEEN IT**

CHRISTOPH KALTSEIS/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

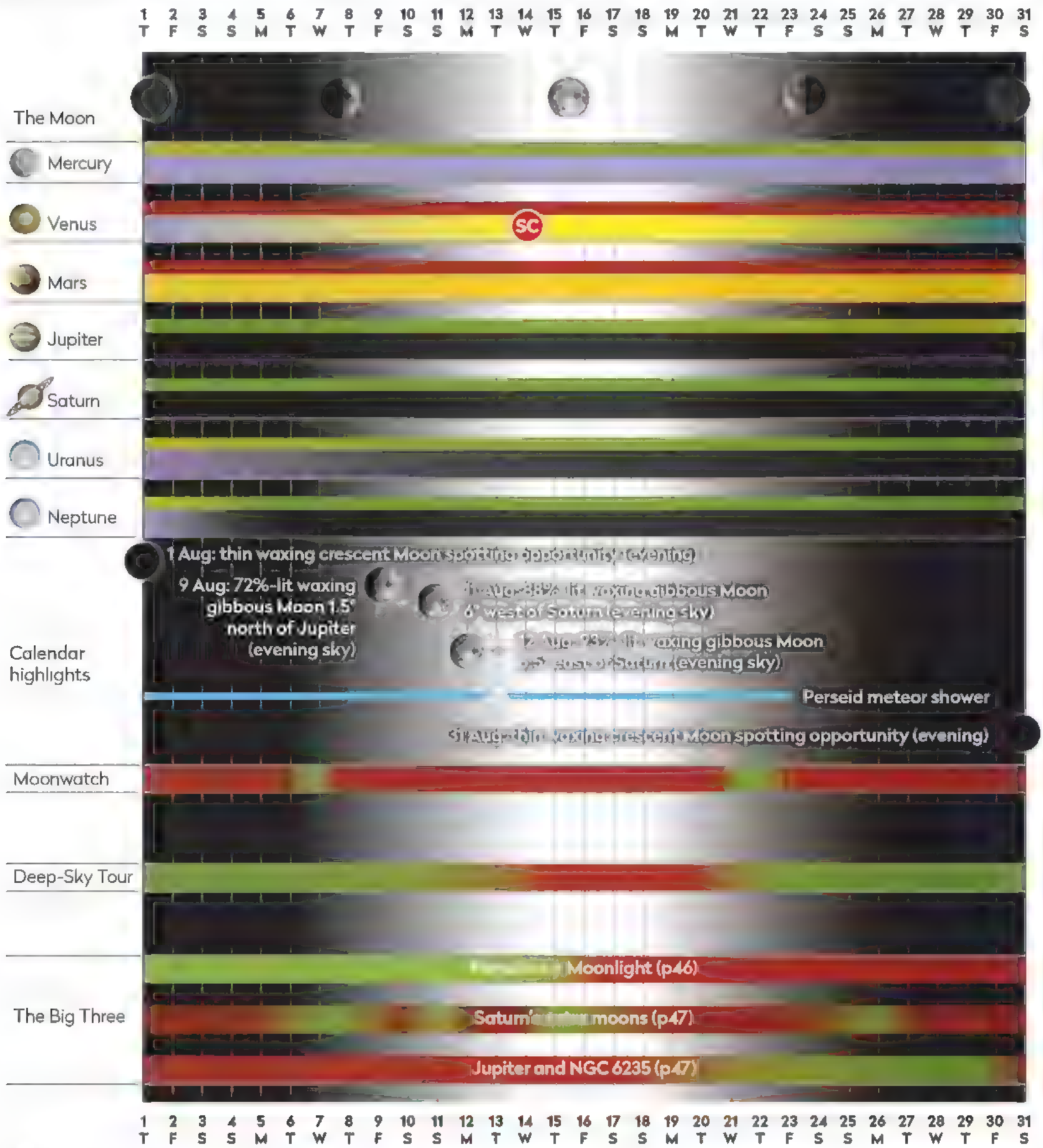
More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.


CYGNUS
LYRA
NGC 6791
5°
2°
N
E
S
W
Vega
Sheliak
Sulafat
Albireo
Stephenson 1
Minkowski 1-64
M57
M56
NGC 6765
PK 064+05.1
Minkowski 1-92
19h30m
19h00m
18h30m
19h
+40°
1
4
5
6

AT A GLANCE

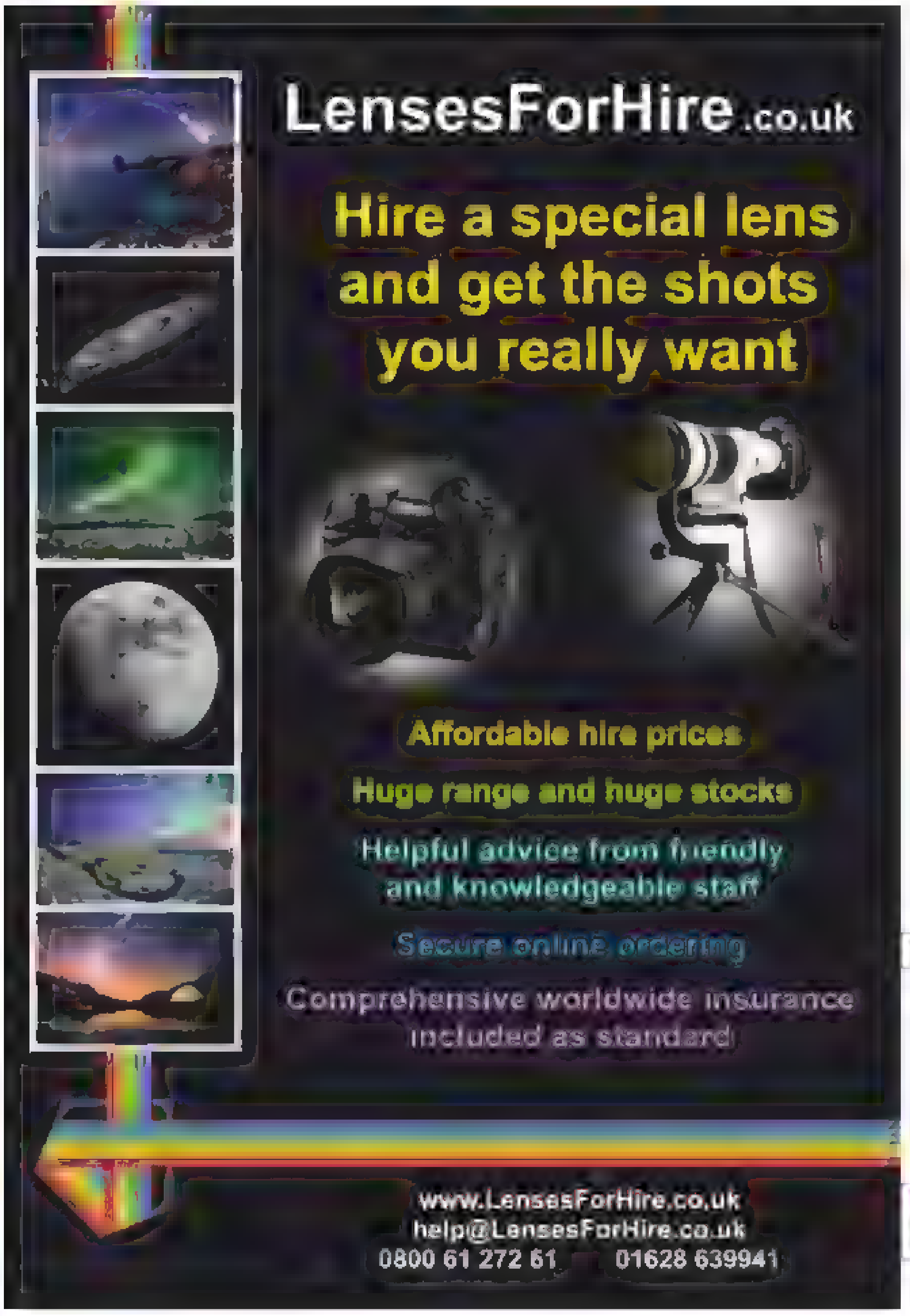
How the Sky Guide events will appear in August



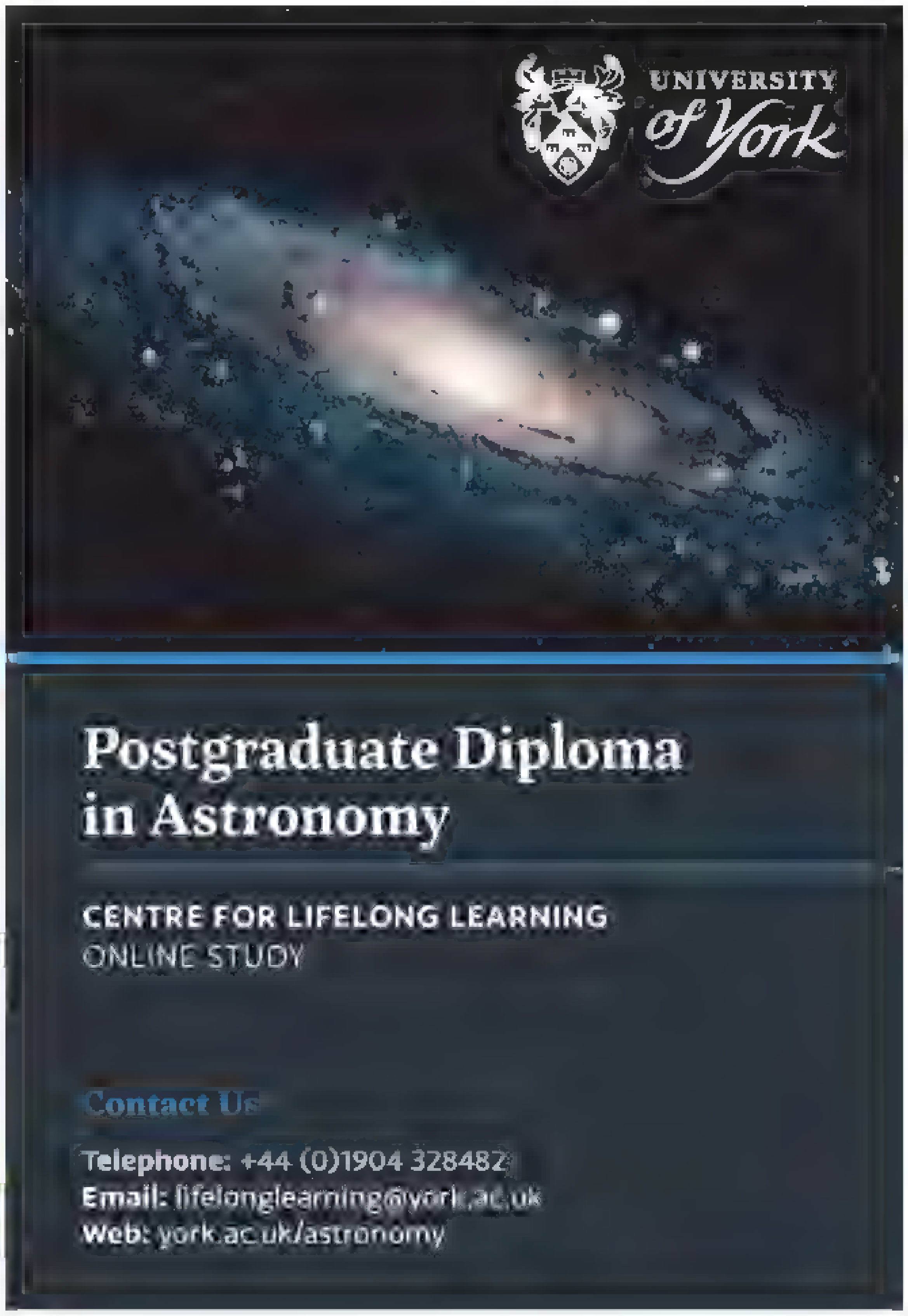
KEY

CHART BY PETE LAWRENCE

CELESTRON®
NEW
PRODUCTS
Only available from
selected astronomy
WiFi
22084
NexStar 5" SLT SCT
£549
INCLUDES A
ADAPTER
Smartphone not included
DAVID HINDS LIMITED
@David_Hinds_Ltd
22088 NexStar 6" SLT SCT £649
22205 AstroFi 6" WiFi SCT £649
David Hinds Ltd is an authorised distributor and reseller of Celestron products.
NEW
celestron.co.uk
Celestron®, NexStar™ and AstroFi™ are registered trademarks or trademarks of Celestron Acquisition, LLC in the United States and in dozens of other countries around the world. All rights reserved.



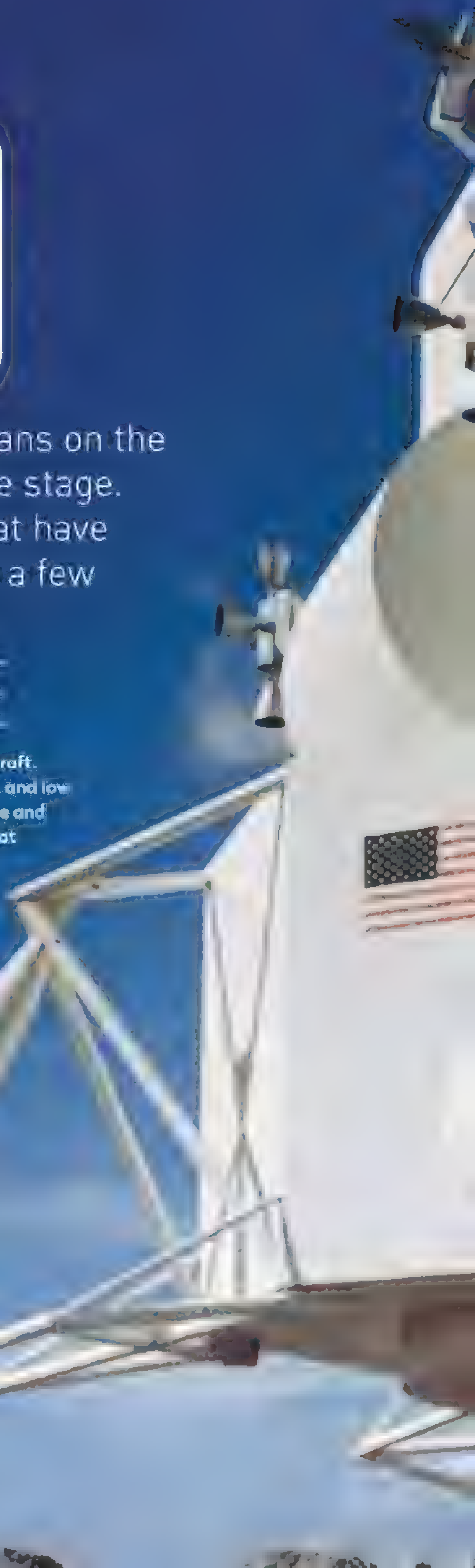
LensesForHire.co.uk
Hire a special lens
and get the shots
you really want
Affordable hire prices
Huge range and huge stocks
Helpful advice from friendly
and knowledgeable staff
Secure online ordering
Comprehensive worldwide insurance
included as standard
www.LensesForHire.co.uk
help@LensesForHire.co.uk
0800 61 272 61 01628 639941



UNIVERSITY of York
Postgraduate Diploma
in Astronomy
CENTRE FOR LIFELONG LEARNING
ONLINE STUDY
Contact Us
Telephone: +44 (0)1904 328482
Email: lifelonglearning@york.ac.uk
Web: york.ac.uk/astronomy

Secrets of APOLLO

In the enormous undertaking to land humans on the Moon the big-ticket items often take centre stage. Yet there were many smaller attributes that have slid into obscurity. Here **Rod Pyle** looks at a few



THE VERSATILE LUNAR MODULE

The lunar module (LM) was an amazing spacecraft. Purpose-built to fly and operate in the vacuum and low gravity of space, it proved to be rugged, reliable and versatile. But it wasn't plain sailing. The LMs that flew on Apollo 5, Apollo 9 and Apollo 10 were all too heavy to land on the Moon. Only with Apollo 11 did a LM fly that could attempt a Moon landing – but this was only capable of supporting the astronauts for about a day.

On Apollo 12, the life support system was upgraded for a two-day lunar stay and two moonwalks. Famously, the [illegible] get the crew of Apollo 13 home safely, when the [illegible] was crippled by an exploding oxygen [illegible] Apollos 15, 16 and 17. Payload [illegible] landings, and life support was [illegible]

[illegible]

Mock-up: Jack Mays of NASA's Crew Systems Division descends from a full- scale model of a lunar lander in 1966, in preparation for the Moon landing mission

Inset: After landing on the Moon, Buzz Aldrin collects equipment from Apollo 11's lunar lander storage hold in July 1969

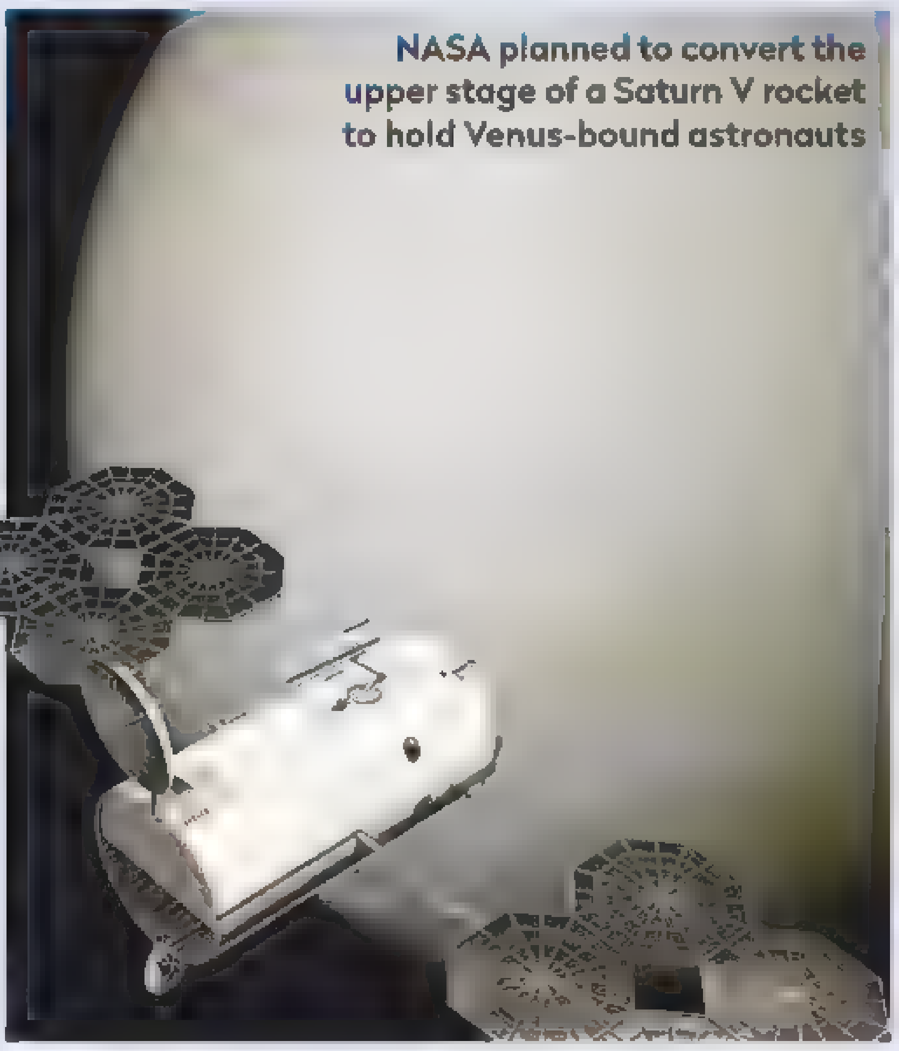
With IBM technology Saturn V's LVDC was its nerve centre; (inset) the assembly of units

SATURN V's AUTOPILOT

The Apollo Guidance Computer that navigated the CSM and LM to the Moon and back is a well-known marvel of 1960s technology. Less heralded is the Launch Vehicle Digital Computer, or LVDC, aka the Instrument Unit another navigational computer housed at the top of the Saturn V's third stage, just beneath the LM.

This 1m-high, 7m-diameter, 2,000kg cluster of boxes that ringed the rocket's fuselage was designed by NASA engineers and built by IBM as a separate, independent nerve centre for the Saturn V. The LVDC was a combination of digital and analogue technology designed to be foolproof during its six-hour service life, until the massive rocket's third stage had propelled the astronauts out of Earth orbit. It fired the rocket engines on each stage, steered the rocket's ascent by swivelling the engines, timed their shutdown, and commanded the stages to separate at the required moment.

The computer saved the day more than once. On Apollo 13 it commanded four engines on the second stage to fire longer, compensating for the centre engine that shut down two minutes early. On Apollo 12 the LVDC continued flying the rocket when the command module was struck by lightning twice – completely knocking out the capsule's guidance computer – and delivered the crew safely into orbit.



NASA planned to convert the upper stage of a Saturn V rocket to hold Venus-bound astronauts

NASA X 8

ONWARD TO VENUS

The lunar missions of Apollo are well chronicled. But there were extensive plans for follow-on missions, of which only 1973's Skylab and 1975's Apollo–Soyuz survived. Starting in the mid-1960s the Apollo Applications Program dreamed up various ways of using Apollo hardware after the lunar landing. These included Apollo-derived space stations, lunar outposts, and a Mars flyby (See the July 2019 issue).

Of these mission plans, perhaps the most inspired was a crewed flyby of Venus. The Saturn V had the power to launch the spacecraft toward Venus, the Apollo capsule would soon be battle-tested via the lunar flights, and the upper stage of the Saturn rocket – the S-IVB stage – could be converted into a habitat for the Venus-bound explorers. The round trip to the planet and back would have taken just over a year, with the crew living in quarters about the size of a small apartment. While their loop past Venus would only last a few hours, they would drop various probes into the planet's atmosphere and conduct astronomy en route from a large telescope mounted on the S-IVB stage.

In the end, the Apollo Applications Program's budget was cut along with the rest of the post-Apollo 17 lunar flights, dooming the more exotic mission plans. But had it been attempted, Apollo's journey to Venus would have been an amazing – if dangerous – journey.

▲ An innovative suitcase-sized PLSS allowed life support systems to become portable

YES, PLSS

When Neil Armstrong stepped onto the Moon, though he had left the LM, he was still inside a flexible spacecraft – the Apollo spacesuit. Critical to its protective abilities was the life support backpack, the Portable Life Support System (PLSS).

The PLSS contained oxygen for breathing and maintaining air pressure, carbon dioxide scrubbers to remove the deadly gas from astronaut exhalations, a radio for communicating and a water supply for drinking and controlling temperature. It even mitigated body odour and humidity with filters.

The PLSS had a lifetime of four hours, and the EVA was limited to two-and-a-half hours for safety. Temperature control was a massive task — the Sun-baked side of the suit could soar to 120°C while the side in shadow dropped to about 65°C. The one-gallon water supply was circulated through undergarments by tiny plastic tubes woven throughout, and excess body heat was expelled by slowly venting the warmed water into the lunar vacuum.

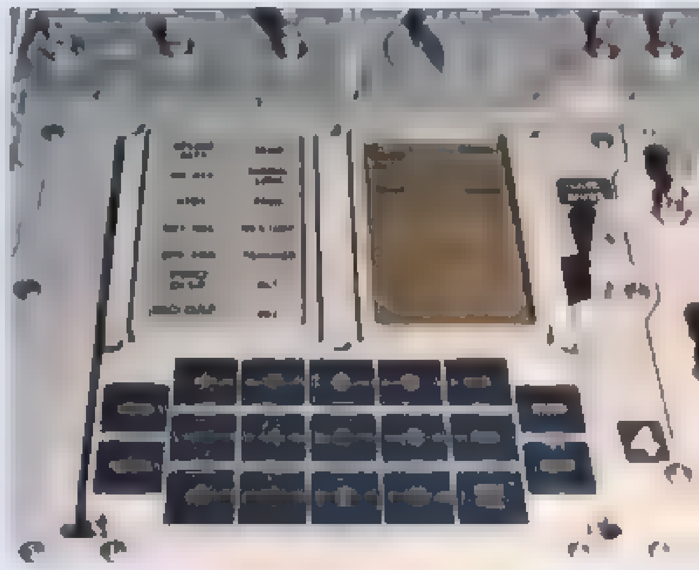
Atop of the backpack was an Oxygen Purge System, which carried more supplies in case of an emergency.

COMPUTER ALARM

Before NASA could send astronauts to the Moon, they had to make sure that spacecraft could navigate across the void between the two worlds. To do so it turned to the Massachusetts Institute of Technology (MIT) to design a new computer and software.

The Apollo Guidance Computer, or AGC, was the result: an ingenious device that crammed a small room's worth of computer into something a bit larger than a briefcase. It did this by using a brand new, and largely untried, technology called integrated circuits utilising magnetic core memory – a lattice of hair-fine copper wire woven through tiny magnetic beads. It ran at 1 MHz, with 2k of RAM and 36k of ROM; about the same as the first Apple II computer from 1977.

The AGC proved to be robust in use, as witnessed in the landing of Apollo 11. With the computer controlling descent to the surface, the AGC locked up with 1201 and 1202 error codes. This was a data overflow: the computer would have been at risk of crashing were it not for clever software design. Due to this code the processor knew which tasks to disregard and which were critical.



▲ Apollo's AGC delivered the Eagle's crew safely to the lunar surface

CONTROLLED CHAOS

The raw power of the Saturn V's F-1 engines was harnessed by its injector plate (inset)

The Saturn V remains the world's most powerful rocket thanks to the five massive F-1 rocket engines that powered its first stage. Most rocket engines of this era offered about 700kN of thrust – impressive, but only one-tenth of the F-1's target of 7,000kN. And while some components of rockets can be scaled up with moderate reengineering, the F-1's development turned out to be much more complicated. Early tests resulted in exploding engines and engineers cringing in concrete blockhouses. This beast had to be tamed; easier said than done in an era of slide rules and primitive computers.

With the 1969 deadline looming, the cause of these failures had to be found and corrected quickly. By combining extensive testing, close observation and a lot of intuition, the engineers realised that the engine was experiencing 'combustion instability'. Fuel burned unevenly and compression waves built up, banging back-and-forth inside the engine, until it simply shook itself to pieces. Many fixes were attempted, but over time designers singled out the injector plate, a 1m-wide metal disk with 6,300 small holes, through which fuel was sprayed on its way to fiery annihilation.

By experimenting with the number and orientation of these holes — and with configurations of the baffles that separated them, the clever engineers were able to bring the F-1 to heel, successfully firing it for well over the two minutes it was required to burn during an Apollo launch. Throughout the programme, the F-1 was a sterling performer, with no catastrophic failures in flight.

Rod Pyle is the author of 15 space books and editor-in-chief of *Ad Astra* magazine for the National Space Society

Apollo conspiracy theorists often claim the Moon landing was filmed in a TV studio

MOON LANDING CONSPIRACIES

CRUSHED

Dallas Campbell sets out to bust the Moon landing myths once and for all

The Apollo 11 Moon landing remains our finest hour, yet there are some who would rather believe it was faked to convince the world the US had beaten the Soviets in the Space Race. Where did this idea come from? For that we can thank Bill Kaysing's 1976 book *We Never Went To The Moon – America's Thirty Billion Dollar Swindle*, which sold during the growing political mistrust in the post-Vietnam, Watergate era. The central premise of the conspiracy lay dormant for a while but gained new life on the internet, and has now implanted itself in a younger, mainstream audience. How should we respond to these allegations? We can be entertained by them – after all, who doesn't love the idea of being in on a big secret? We don't recommend following Buzz Aldrin's example when he punched conspiracy filmmaker Bart Sibrel in 2002. Perhaps instead we can talk about Apollo with the wonder it deserves. But in case you are confronted by these claims, here are some solid rebuttals for you to use. ▸

NASA

▲ **Armstrong and Aldrin took a while to set up their flag. The flag only moves for moments after they handled it**

A fluttering flag

▸ The laws of physics still apply on the Moon. The flag (bought from a local store in Houston for $5.50) was hemmed at the top so that it hung from a horizontal crossbar fixed on top of the pole. We see the flag move when the pole is twisted into the ground by the astronaut. Because there is no air resistance, any residual flag fluttering lasts marginally longer than it would in an atmosphere. You'll notice that the flag only moves when (or moments after) the astronaut has handled it.

Crossing the deadly Van Allen Belts

Deniers enjoy focusing on the Van Allen Belts as an impenetrable barrier. These are areas of geomagnetically trapped, high energy particles that surround Earth. But a path was set to avoid the most hazardous regions of the belts and the astronauts weren't in this region for very long as they sped to the Moon, shielded by the skin of the spacecraft. Any potential radiation hazards were accounted for and flights were scheduled when there were no major solar weather events. Personal dosimeters (that measure radiation exposure) were worn by all the astronauts and exposure was low, no more dangerous than, say, an X-ray. Scientist James Van Allan himself dismissed the idea as entertaining nonsense.

Shadows and lighting anomalies

Non-parallel shadows? Suspicious multiple light sources? Light fill when the astronauts should be in shadow? Evidence, not of a clandestine cover-up, but of the accusers' lack of photography and lighting knowledge. You can have non-parallel shadows from a single light source simply because of perspective, and the uneven topography of the Moon's hills dips, bumps and lumps. Uneven topography can also affect shadow length. The lunar surface reflects around 8 per cent of the sunlight that falls on it (albedo), illuminating areas – like Buzz Aldrin coming down the lunar module ladder – that might seem like they should be in shadow. Sunlight was also reflected off the aluminised Kapton foil on the lunar lander and the white spacesuits, as well as off Earth itself as 'earthshine'. There are no smoking guns in the photographs. Only evidence of our brains seeking patterns.

NASA X 7 PHOTO 12/ALAMY STOCK PHOTO

Evidence is all around

Not all proof of the Apollo landings was broadcast from the Moon's surface

Deniers always fail to account for the vast mountain of direct evidence: the 382kg of Moon rock brought back and studied by scientists; the abrasive lunar dust that still covers the spacesuits; the laser ranger reflectors left on the Moon, which enable scientists to make precise measurements of its distance by firing a laser at them from Earth; the Lunar Reconnaissance Orbiter (LRO) currently in lunar orbit which lets you see with your own eyes the Apollo landing sites; the fact conspiracy theorists often talk about faking the Moon landing, singular – we travelled to the Moon nine times and landed on it six times. Those would have to have been faked too. That's an awful lot of wool to pull over people's eyes. If it was faked, wasn't once enough? And of course, we have the testimony from those who worked on the project and who made the journey that are still with us today. Are they still keeping it a secret 50 years later?

For the conspiracy mind it's not about the official 'evidence'. It's about seeing patterns that reinforce a personal world view. The facts are this: for a brief moment in human history we touched the unobtainable. We made the impossible possible. It's sad that some of us can only imagine such a bold endeavour being possible as a work of fiction. Perhaps one day soon we will show we still have that vision, optimism and confidence, and return to the Moon again. And this time maybe stay a while.

▲ **Apollo 14 astronauts Edgar Mitchell and Alan Shepard examine some of the rock samples they brought back from the Moon**

A technically impressive yet obviously fictional scene from Stanley Kubrick's *2001: A Space Odyssey* showing a lunar base

No stars in the background

There appears to be a lack of stars because the brightness of the lunar day overpowers their faint light. The Hasselblad cameras had their exposure and shutter speed set to capture the activity in the bright foreground, so fainter background stars didn't show up on the film. To photograph faint stars, you need a long exposure and wide aperture. If they'd done that, all the photos would have been overexposed

► The Saturn V first stages at NASA's Michoud Assembly Facility in 1968. With billions of dollars invested in it, US technology got a big federal boost during the 1960s

Filmed by Stanley Kubrick

In 1961, when President Kennedy made his famous Moon speech, the technology to get humans there and back didn't exist. Astronaut Alan Shepard had only made America's first 15-minute suborbital flight that year. But in eight years, with the investment of billions of dollars, 400,000 people working for thousands of different companies making rockets, spacesuits, landers, guidance computers and flagpole assemblies made it happen. But only just! What would have been technologically impossible at the time was to fake it in a studio – video camera technology (used to relay TV footage back to Earth) was primitive, as were film special effects. Brilliant as Kubrick's *2001: A Space Odyssey* was, the scenes on the Moon's surface are hardly realistic. Films like *Diamonds are Forever* which sees Sean Connery as James Bond interrupting a staged Moon faking scene, and *Capricorn One* about a faked Mars mission have amplified the idea that the Moon landings took place in a film studio.

▼ Buzz Aldrin is illuminated by sunshine bouncing back from the highly reflective lunar surface, despite standing in the shadow of the lander

Why haven't we been back since?

Apollo was prohibitively expensive, hazardous, and ultimately unsustainable. Once Kennedy's grand challenge had been accomplished there was neither the political incentive nor budget to keep it going. However, we are going back to the Moon. Perhaps very soon. But as ever, such big-ticket projects are at the discretion of short, fickle political cycles, financial priorities, and most importantly, the public appetite.

Dallas Campbell is an author and broadcaster. He has presented *The Sky at Night* and *Stargazing Live*, and has written *Ad Astra: An Illustrated Guide to Leaving the Planet*

The Great British FIREBALL HUNT

A growing network of dedicated cameras is scanning UK skies to aid the recovery and investigation of meteorites, as **Paul F Cockburn** reveals

Matter from space continues to fall from the sky all the time; an estimated 40,000 tonnes of it every year in fact. Most are the size of grains of sand and don't make it through the atmosphere, but if a meteor is sufficiently large or dense, at least part can survive all the way to the ground – when it becomes a 'meteorite' – usually following a spectacular light show in the sky.

If we can observe and record those tracks of light – known as 'fireballs' when they are particularly intense – and calculate their paths through the atmosphere, then it's possible to work out two things: where the surviving meteorites land, aiding their recovery for study; and their original orbits, from which we can in turn imply their points of origin.

"One meteorite of a searchable size should fall on an area the size of the UK every year," says Dr Luke Daly of the School of Geographical and Earth Sciences at the University of Glasgow. "We haven't found one for 30 years, so we're batting way below our average."

Hoping to change that is a network of digital cameras that Dr Daly is helping set up called the UK Fireball Network (UKFN), part of the Global Fireball Observatory that has grown out of the highly successful Desert Fireball Network in Australia. "The idea originally was to see if we could use cameras to see fireballs and hunt meteorites in a place where we can actually recover them easily," says Daly. Meteorites are little black rocks that are easy to see in a red barren desert.

"Now that we know that it works, that we have our triangulation data pipeline all automated, and we [can] find meteorites at the end of those trails, the idea is to start putting this back into areas like the UK, where it's slightly more challenging to find meteorites, but where there are a lot more people who might see the fireballs."

There are currently some 60,000 meteorites held in collections around the world. Down the years we've studied them and learned a lot but, with relatively few exceptions (like when we know they originated on the Moon or Mars), we don't know arguably the most important thing about most of them: exactly where in the Solar System they came from.

"It's like trying to reconstruct the geological history of Earth from 50,000 random rocks dumped in your back garden," says Daly. "And we're doing this for something the size of the Solar System!"

By the time you read this, UKFN should have six digital cameras pointing to the skies covering England, Wales and southern Scotland. A further five, it is hoped, will go into Scotland and Northern Ireland to fill that gap.

National network

Each camera – although 'autonomous digital observatory' is probably closer to the mark when describing them – comes with around 24 terabytes of storage and can communicate with its neighbours via the internet. They can sit there for a year and a half, happily working away, taking a thousand images a night per camera. There's an onboard computer with a machine learning 'event detection' algorithm that detects things that look like fireballs, and notifies all the other cameras if it sees something. If they also made a detection, the project's scientists get an email with a snippet of each image ▸

MICHIKO SMITH/ALAMY STOCK PHOTO


A fireball streaks across the night skies of West Yorkshire. The cameras of the UK Fireball Network will help to locate where meteorites end up

The potential of the UK Fireball Network (UKFN) is dramatically shown in this image of a fireball captured over Belgium (inset), 300km away, by cameras stationed in the UK

Dr Luke Daly appeared on *The Sky at Night* in September 2018 with an early UKFN camera

▲ **Each UKFN camera will help track meteorites. The camera has a fisheye lens to monitor the entire night sky and will take exposures of 30 seconds**

▸ showing the feature that the cameras found. It's an automated pipeline: it does the triangulation calculation and a rough estimate of the trajectory and mass, before Daly and his colleagues see the data.

Number crunching

That, in itself, involves a lot of computational power, as deciding whether a meteor has survived the journey to solid ground is challenging. "It's a very complicated series of mathematical formulae with loads of unknown variables," Daly points out. "One of my colleagues has done a very good job of numerically modelling all the possible variables and then tying those into the data received; the system basically follows through the parameters that fit the data the best. Normally it will come up with a few solutions, most of which have no mass, but if there are a few that do have mass, there's more likely to be a rock at the end of that.

"I don't pretend to understand the computing side of it. I just know enough to be able to tell people that it's complicated, awesome and seems to be predicting meteorites to within 200m of where they should be, with the caveat that when we find them, they've been within 200m of the predicted fall area."

Daly is well aware that he's not the first at this particular scientific table. Coordinated by staff at the Natural History Museum, the UK Fireball Alliance (UKFALL) is a collaboration that brings together UKFN, the UK Meteor Observation Network (which has been recording and sharing fireball images since 2012), SCAMP (System for Capture of Asteroid and Meteorite Paths), an off-shoot of the French FRIPON network), and other amateur astronomy groups that have cameras on their roofs. "We've got a protocol in place for when the 'big one' happens, how we go about recovering that rock," says Daly. "It'll be a group of volunteers and scientists going out doing glorified body searching in the middle of a field somewhere!"

Already in place are data-sharing agreements. "If we see a fireball jointly, we've been sending each other our data and putting it through our models. It's a sort of double-check that we're all getting the same numbers. There's no point in competing; we all just work together. We've had a few joint observations

Paul F Cockburn is an astronomy and science journalist

UK FIREBALL NETWORK AND THE GLOBAL FIREBALL OBSERVATORY, SPACE SCIENCE AND TECHNOLOGY CENTRE/CURTIN UNIVERSITY X 2, BBC, HADRIEN DEVILLEPOIX, BOGDANSERBAN/ISTOCK/GETTY IMAGES

Fireballs on your phone

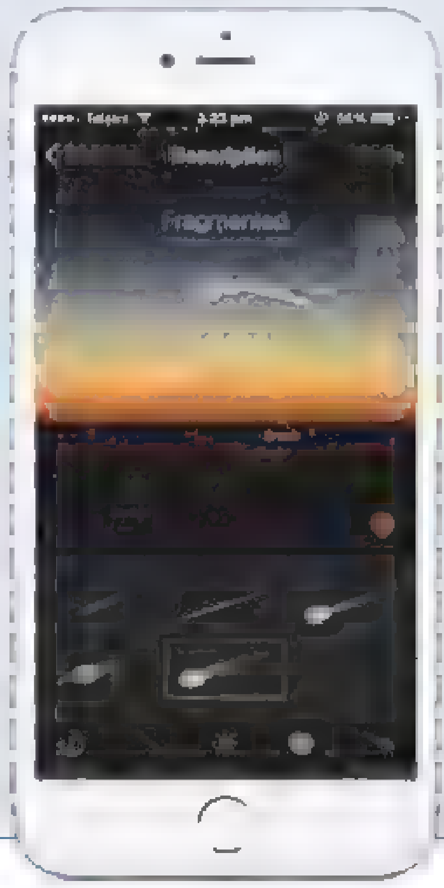
With the help of a smartphone app, you too can get involved in the hunt for meteorites

The Fireballs in the Sky app (**fireballsinthesky.com.au download app**) enables you to get involved with Global Fireball Observatory research by reporting your own meteor sightings to astronomers, who then use your data to help track the trajectories of meteors from their orbit in space to where they might have landed on Earth.

If you see a fireball you point your phone at the sky where you saw it, click, and record how long it lasted, what colour it was, how bright it was, whether it broke up, and whether you heard a sound.

"People seem to be quite good at getting this correct, so we've been able to use data from the app to find the likes of the Dingle Dell meteorite in Australia," says Dr Luke Daly. "The more people that use the app, the tighter the constraints on observed meteors' trajectories and the better our models will be, so the more likely we are to find a rock at the end."

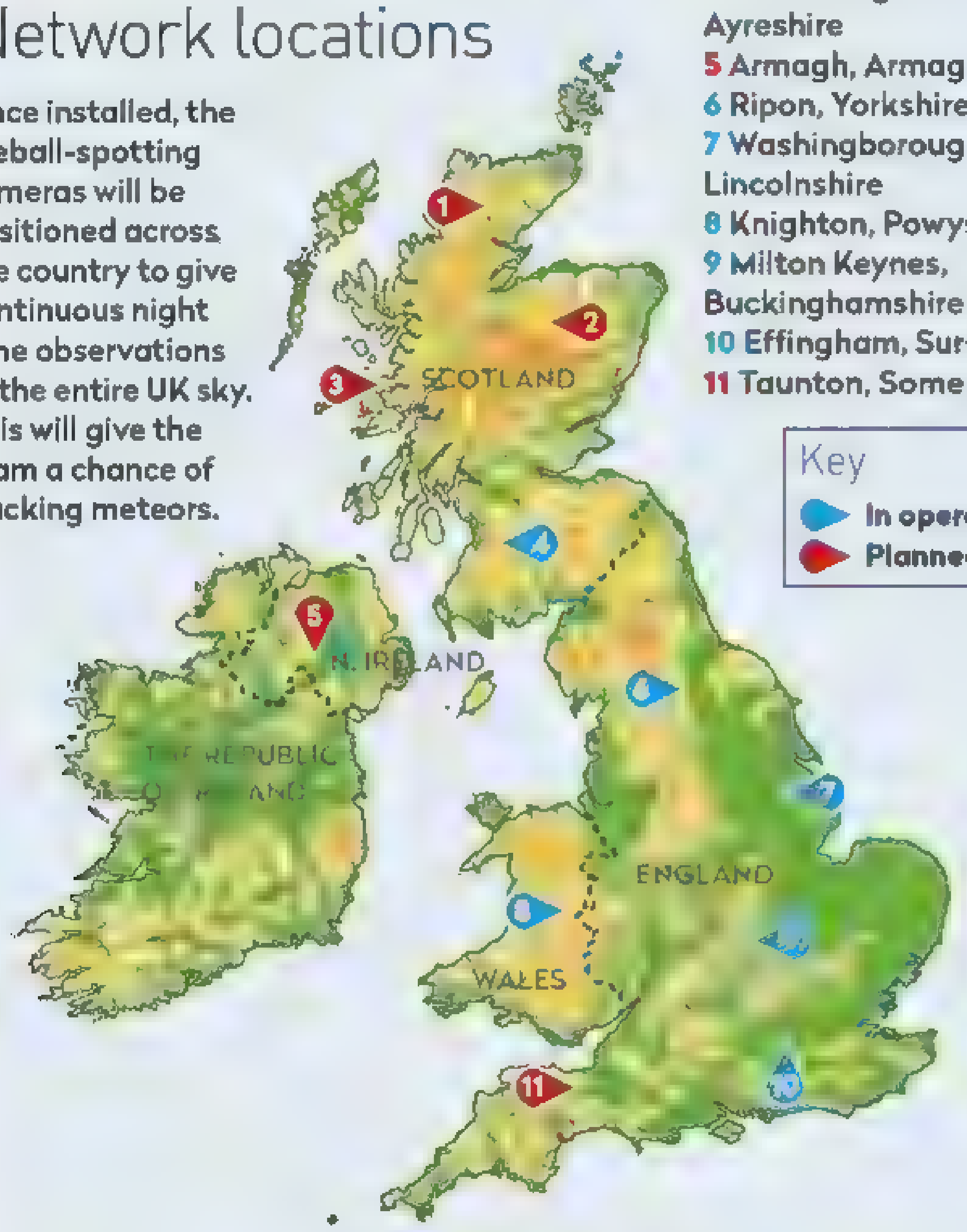
The app available to iOS and Android users also helps you to view expected meteor showers.



UK Fireball Network locations

Once installed, the fireball-spotting cameras will be positioned across the country to give continuous night time observations of the entire UK sky. This will give the team a chance of tracking meteors.

1 Lairg, Sutherland
2 Nethy Bridge, Strathspey
3 Tobermory, Mull
4 Dalmellington, Ayreshire
5 Armagh, Armagh
6 Ripon, Yorkshire
7 Washingborough, Lincolnshire
8 Knighton, Powys
9 Milton Keynes, Buckinghamshire
10 Effingham, Surrey
11 Taunton, Somerset



▲ **The Dingle Dell meteorite, weighing 1.15kg, was located in Australia using reports from the public**

recently where we've been basically seeing how fast we can turn around calculating an orbit and triangulation, and it seems to be pretty quick."

Getting involved

For now, the best way *BBC Sky at Night Magazine* readers can get involved with UKFN is via a smartphone. Originally developed for the Desert Fireball Network, the Fireballs in the Sky app (available for both iOS and Android users) enables you to record observations of fireballs, taking advantage of your smartphone's in-built GPS and gyroscope.

"Multiple observations [of fireballs] from the app turn out to be way more useful than we thought they would be," Daly says. An obvious case in point were the several fireball reports made by members of the public in the wheat-belt region of Western Australia in 2016, which helped fine-tune the search that led to the successful recovery of the near-pristine 1.15kg (3.3 lbs) Dingle Dell meteorite.

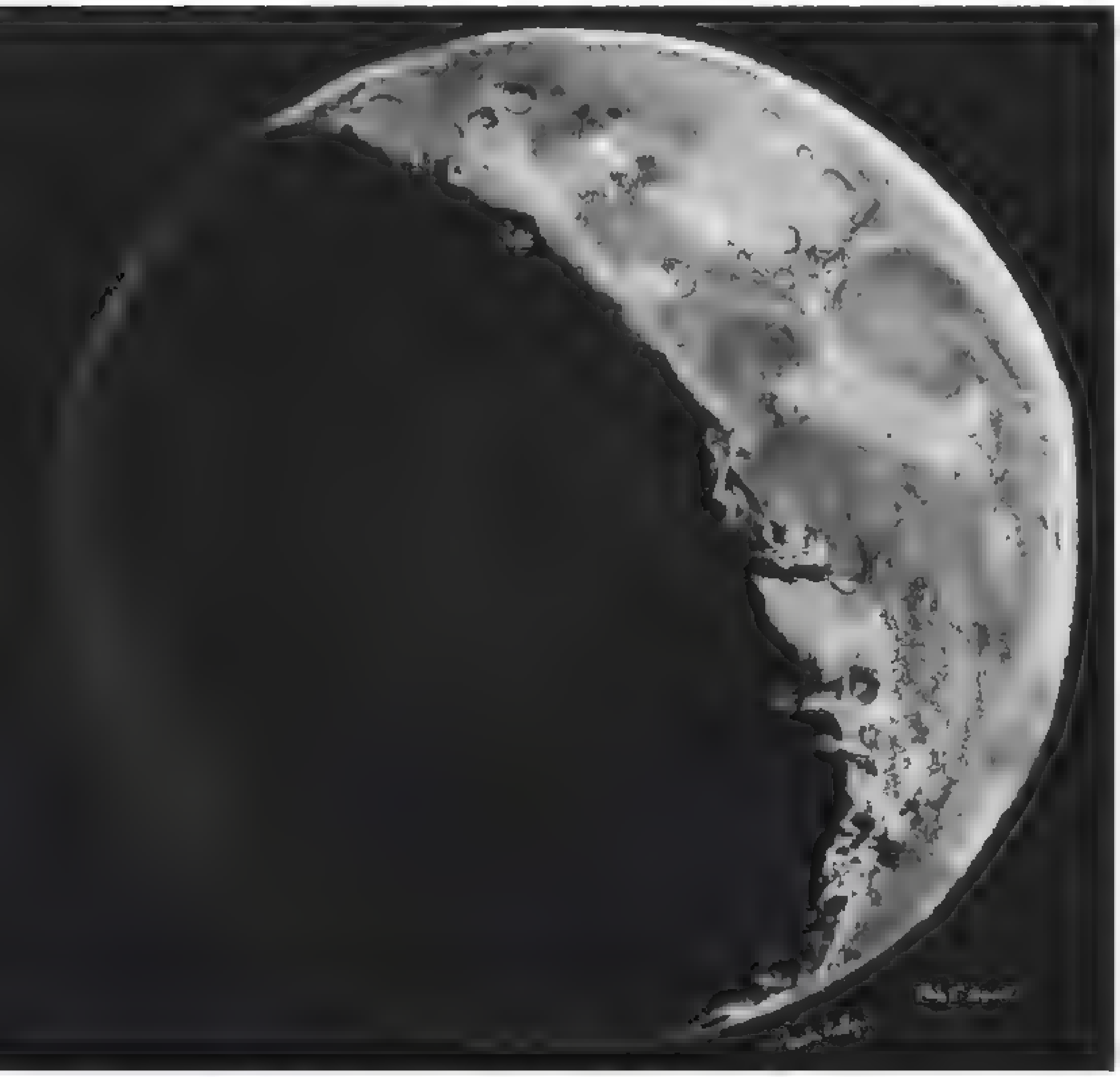
Will their data sets be put out to the wider citizen science community? "I don't think that's the plan, for now at least," says Daly. "For the most part, the app is the main contact. Also, it doesn't just turn your phone into a meteorite reporting device: it tells you when all the big meteor showers are, as well as their altitude, azimuth and maximum. You can use the app to point your phone to where you should be looking for meteors. It also carries updates of the science the group is doing around the world because it's not just the UK network, it's the global fireball observatory."

If Dr Daly and his team's project matches the successes of its Australian counterpart, it could mark the start of a new era in UK meteorite hunting.

EXPLAINER

Getting to know the Moon

There's no better way to familiarise yourself with lunar features than by drawing them



◄ **A finished pastel sketch of a waxing crescent Moon reveals a well-defined terminator and earthshine**

Are you new to observing the Moon? Perhaps you've been inspired by Apollo 11. If so sketching our natural satellite will help you find your way around. All you need is a clear night, a clipboard, paper and pencils – I would suggest a soft 2B pencil and a hard 2H pencil.

Observe the Moon before you begin, paying attention to dark area shapes (the Maria) and the bright areas (the highlands). Closely observe the shape made by the terminator (the line that separates the lunar night and day). You'll find that getting the shape of that line correct is a crucial part of lunar sketching.

Notate each sketch with the date, time in UT, the kit used and Moon phase. Use a Moon atlas to help label the craters and maria; you'll soon learn their names and your way around the lunar surface. Your drawings don't have to be perfect, the point is to learn while having fun making them.

When you start your drawing, use a 50mm circle to help you. A binocular dust cap will serve as a template. Always draw the Moon as a full circle, even if the lunar phase means only part of it is showing.

Deirdre Kelleghan is an artist, astronomer and co-author of *Sketching the Moon: An Astronomical Artist's Guide*

Drawing with the naked eye

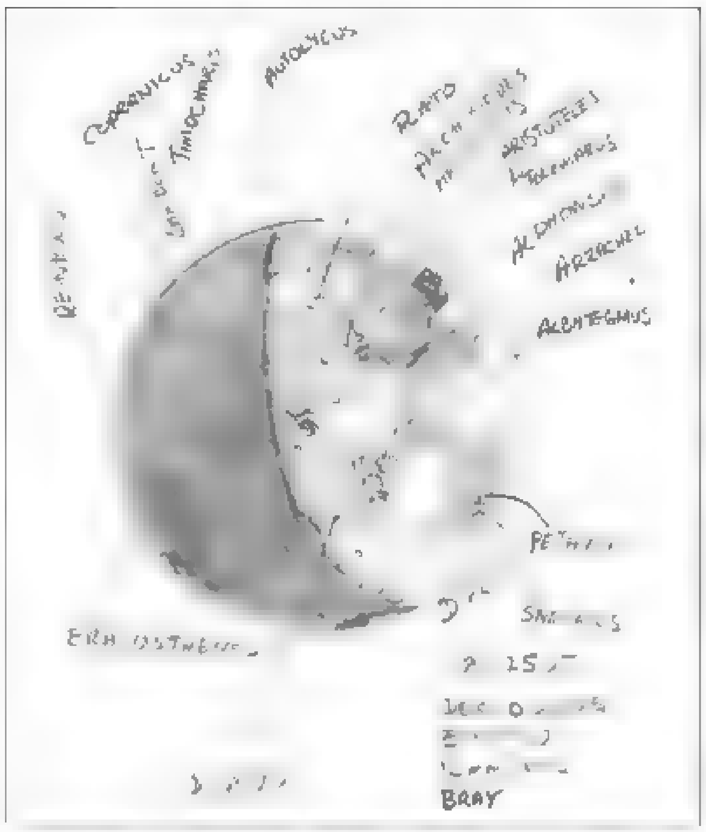
Naked eye drawing can tell you a lot about the Moon. When it's waxing away from new Moon the terminator offers a north to south curved line, becoming less curved as it hits a dead straight position at first quarter Moon. After that the curve becomes more pronounced as the terminator moves towards full Moon. The terminator then takes up a position around the circumference (limb). At this point the far side is in total darkness and the near side is in full sunlight.

If the Moon is a few days before or after a new phase you may see the phenomenon of earthshine – where light is reflected from the Earth back onto the Moon's unlit section. It causes a faint illumination of the unlit lunar surface; to the eye its features show up faintly. To simulate the effect when drawing earthshine the trick is to remove some pencil markings with an eraser.

Through the eyepiece

With binoculars, the detail you encounter will increase dramatically. You should be able to see crater rays, caused by explosive impacts on the Moon, kicking up long plumes of dust across the lunar surface. An eraser can help with the addition of rays by removing pencil in dramatic flicks. Rays and other detail on the surface look more stunning when they are located along the terminator. It is then that the contrast between dramatic whites and the black shadows is profound.

For this you will need a pair of binoculars that can be screwed into a tripod as they need to be absolutely steady. A pair of 10x50s are perfect for beginners. As your binoculars will show you more detail you can increase the size of your drawing circle to 120mm. A CD is perfect for this task. You may wish to continue using pencils or you could try venturing into pastels. Using



▲ **The author's pastel setup (left) and lunar location sketches, drawn from looking through binoculars (middle) and a small telescope (right)**

pastels requires black card, black and white soft pastels and as many greys as you can find. This medium allows for blending and the creation of depth, which looks great when your targets are lunar craters and mountains. Draw the larger features first and then add additional craters in different areas.

Introducing a small scope increases the detail once more. Use an erecting prism to keep things upright. A dinner or side plate circle is a good size for full phases, though a scope also allows you to zoom in on craters.

As the phase of the Moon changes, it can give features different appearances. Plato, a crater in Mare Imbrium, can have shadows cast into it by the Sun that look like flames. Mountains like Mons Pico appear as pointed bright lights against the grey lunar surface.

Over time you will build up a collection of lunar drawings. In doing so your familiarity with our Moon will become permanent knowledge as you develop your skills as an astronomer.

Observe and sketch

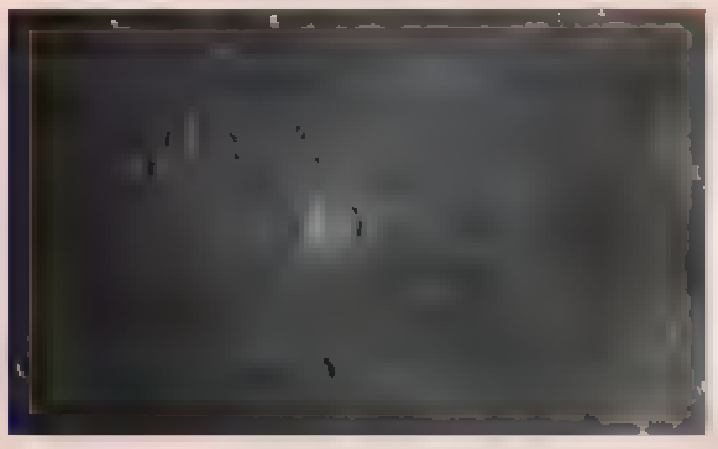
Whatever your skill level and equipment, there's plenty of Moon features to locate and draw

The maria

The Moon is covered with several dark 'seas'. As long as part of the Moon is illuminated, at least one of these should be visible.

Earthshine

The reflected light of Earth illuminates the Moon for a few days around new Moon, though you might have to get up early to catch it.



Copernicus

It's easy to find this crater with binoculars due to its prominent ray system. With a telescope, you should make out the crater's hexagonal shape.

Tycho

The Tycho crater has another prominent ray system, but can be trickier to make out, due to a lack of contrast with nearby lunar highlands.

Plato

The angle we view Plato crater at gives it a 'squashed' appearance. The irregular ring casts interesting shadows when the terminator's close by.

Eratosthenes and Montes Apenninus

The rugged Apennine mountain range reaches 5.5km in height and extends 600km before terminating in a deep crater with terraced walls.

Build your own quadrant

Our guide to constructing a table-top version of a classic astronomical instrument

This project is a table-top quadrant, which is derived from the astrolabe (in the July issue) and similar instruments used for surveying and navigation. The quadrant's purpose in astronomy is to accurately point to objects in the sky and record their position relative to the observer. It works the other way too: if you know where an object is the quadrant can be aimed towards those coordinates so that it can be viewed with the naked eye or binoculars.

The quadrant has two elements; the base with a disc (and a scale marked out in 360° increments) and a central pivot for the top of the instrument, plus the pointing arm, mounted to a vertical beam via a 90° scale and horizontal pivot. The arm can be moved in all directions and, by carefully adjusting the friction of the pivots, it holds position so you can read off the indicated values on the scales.

The quadrant uses coordinates in altitude and azimuth. Altitude is measured in degrees above the horizon – 0° represents the horizon and 90° is the zenith directly overhead. Azimuth is also measured in degrees – due north of the observer is 0°; east is 90° and so on. The altitude-azimuth system is simple to understand, and the instruments are easy to make but the coordinates of an object in the sky differ for observers in separate locations and also vary during the night. In order to establish the coordinates of an object you need to know your location and time of observing. There are apps and websites which display this; for example, the web-based planetarium **www.staratlas.com**. After entering your location in Star Atlas, select an object in the sky then click on it. Within the list of information displayed, you can read off its altitude-azimuth coordinates. If you are preparing for an evening's observation you can 'fast forward' to the time you plan to be out and make a note of the times and positions of targets or, of course, you could take your laptop or tablet with you.

To set up your quadrant place it on a garden table. To make viewing more comfortable it's a good idea to be sitting with the table between you and most of your targets. Next, you must ensure it is level. For this we used a smartphone app with a built-in spirit level. You can level it by adjusting the wedge-shaped blocks below the base. Finally, you need to set the azimuth scale so that the 0° mark faces north. This could be done using a compass, but a good method is to point the main arm towards Polaris and then turn the disc (adjust the friction so this is fairly tight), so the pointer falls on the zero mark. Take care not to jog the azimuth disc when moving the arm onto each new target.

Tools and materials

- Marking out tools, including a ruler, square, compass and pencil; a coping saw or similar; a hacksaw, drill and bits for M4 and M6 screws; a scalpel or craft knife and files or sandpaper for smoothing.
- Two plywood sheets (A4) one 3mm and one 6mm thick; wood for base, 18x18mm and 600mm long; aluminium channel, 19.5x11.5x1.5mm and 800mm long; aluminium strip, 11.5x1.5mm and 500mm long.
- Sundries include 20 M4x12mm screws with nuts, four M6x40mm CSK screws with one Nylock nut and three wingnuts and washers, and a couple of M4 Nylock nuts and washers. You will need a small piece of felt, offcuts of wood for wedges and double sided tape and glue.
- To finish the plywood, apply primer and spray paint or varnish.

A quadrant is both functional and educational

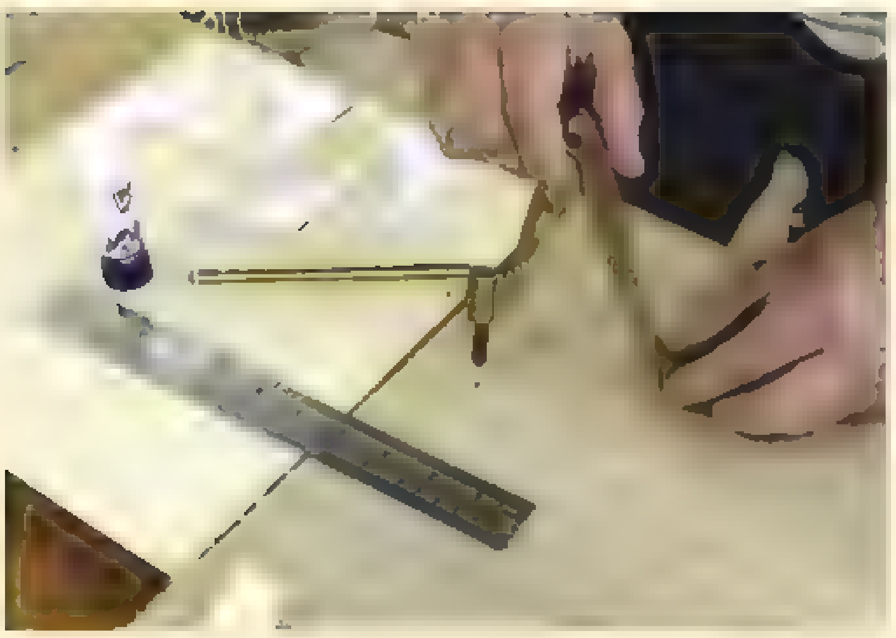
ALL PICTURES: MARK PARRISH

Mark Parrish is a bespoke designer. See more of his work on his website: buttondesign.co.uk

More ONLINE

Download plans, diagrams and more photos for this project. See page 5 for instructions

Step by step



Step 1

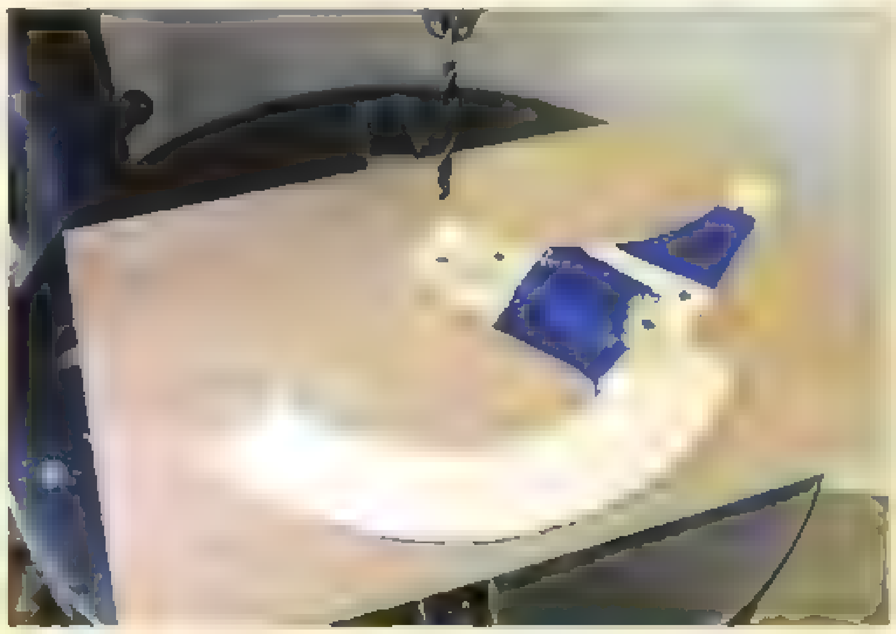
Print out the templates for the support brackets. Draw round them or stick them to the plywood ready for cutting out. We used a compass to draw the circle for our base disc. Although 3mm plywood is good for the brackets, the base can be thicker.

Step 2

Using a coping saw, carefully cut out the brackets and base disc. We taped the identical lower brackets together and cut them in one go. Use files and sandpaper to ensure a good finish. Mark where any holes will go before removing templates.

Step 3

Use a hacksaw to cut the aluminium. If yours is a different size, check the lengths first by laying them out on the bench with the brackets. It's a good idea to support the channel when cutting by inserting a closely fitting piece of scrapwood.



Step 4

Hold your brackets against the channels to establish desired hole positions. We taped the tops and bottoms together before drilling, so the holes lined up. Use the finished brackets to transfer marks to the aluminium and drill again.

Step 5

Cut the two base pieces. Make a 10° slope on the underside of the three ends of the 'T' and a 6mm wide slot. Cut three small blocks of wood to make the wedges and glue an M6 screw into each. Wingnuts and washers complete the wedges.

Step 6

After painting, stick on the scales and assemble using the small screws and nuts. Add a small strip of felt to the underside of the lower bracket. Make a paperclip pointer and add a washer and pointer to make the sights on the arm.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Saturn's inner moons, from Mimas to Titan, make interesting animation targets

On the trail of Saturn's satellites

Tips for imaging the gas giant's innermost moons

Saturn has been a low altitude object from the UK for several years now and will remain so for several more. This makes high-resolution imaging of the planet difficult because of the turbulent atmospheric conditions found near the horizon. However, there is still plenty of opportunity for imagers, and one subject that is satisfying to attempt is that of recording and animating Saturn's moons.

Like Jupiter, Saturn has a large family of moons. At the last count there were 62 which had official designations. Many of these are tiny and too small for amateur instruments to see. Out of the 67 officially recognised moons orbiting Jupiter only four are easily within amateur range. These are the so-called Galilean moons; Io, Europa, Ganymede and Callisto. Saturn fares better and there are eight moons within amateur range. These include Mimas, Enceladus, Tethys, Dione, Rhea, Titan, Hyperion and Iapetus. Mimas is tough because it never strays far from the edge of the rings while Hyperion is difficult because it's the same sort of brightness as Pluto at around mag. +14.5.

Iapetus is interesting in that its brightness changes depending on which side of the planet it appears on and its orbit is reasonably inclined to that of Saturn's equatorial plane. The outer moons are interesting but move on quite a slow timescale.

It's the inner moons, from Mimas to Titan, which are most interesting for animation purposes as they show tangible movement over the course of a night. If you managed to capture Saturn early enough in the evening and keep taking images of it at, say, 15 minute intervals for as long as you can, animating the images together will show the moons orbiting their host planet.

Although this sounds wonderful there are issues that need to be addressed. First, you'll need to have an image scale which is large enough to show the inner satellites. A wide dimension that covers 8–9 arcminutes across is ideal and will contain Titan's orbit.

Then there's the brightness of Saturn itself. This can wash out the inner moons so you'll need to evaluate good settings for a camera to avoid 'planet-burn'. Even if you do get the setting right, you'll need to keep a careful eye on moisture levels. A misty objective or mirror can cause light from Saturn to spread to a larger area which engulfs these moons. Set initial sights realistically. It's great to try for Mimas but it's so close to Saturn that it's often lost. If you fail to detect it don't worry, just add it to a to-do list for the future.

The moons are fascinating to record and animate in their own right. However, Saturn is currently in a Milky Way-rich part of the sky and as the planet moves with respect to the background stars, several will appear to drift through the Saturnian system. Of course the stars are essentially fixed and it's Saturn that's moving, but capturing these appearing to infiltrate the orbiting moons can add another level of interest.

▸ *Turn to page 47 for additional information.*

Recommended equipment: High frame rate planetary camera, a scope on a driven equatorial mount, an optical amplifier such as a Barlow or Powermate


Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

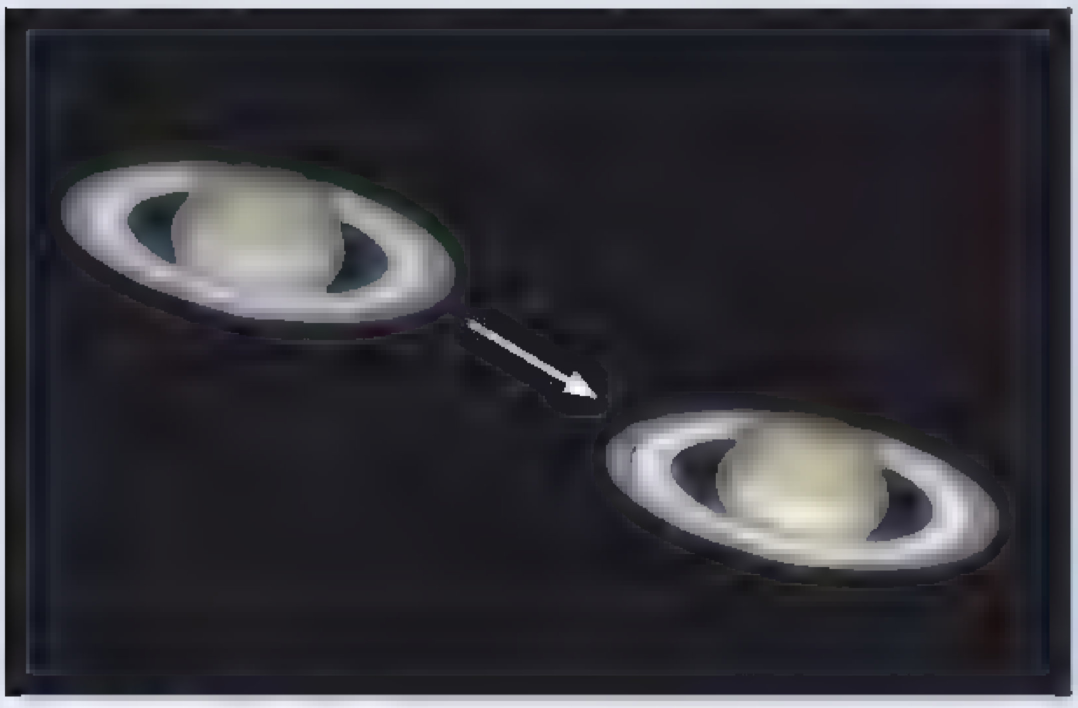
Send your images to:
gallery@skyatnightmagazine.com

STEP 1

Image scale is determined by telescope focal length and camera pixel size. A useful tool for determining your camera's scale before imaging can be found at **www.12dstring.me.uk fovcalc.php**. In 'Camera Mode' select your scope make and model followed by your camera's. It will calculate your field of view.

STEP 2

If your scope's focal length doesn't deliver the desired image scale, an optical amplifier will help. Typical examples are Barlows and Powermates. These have a multiplier which is applied to your scope's natural focal length to create a longer effective focal length. You can adjust the Barlow Reducer in the calculator (Step 1).

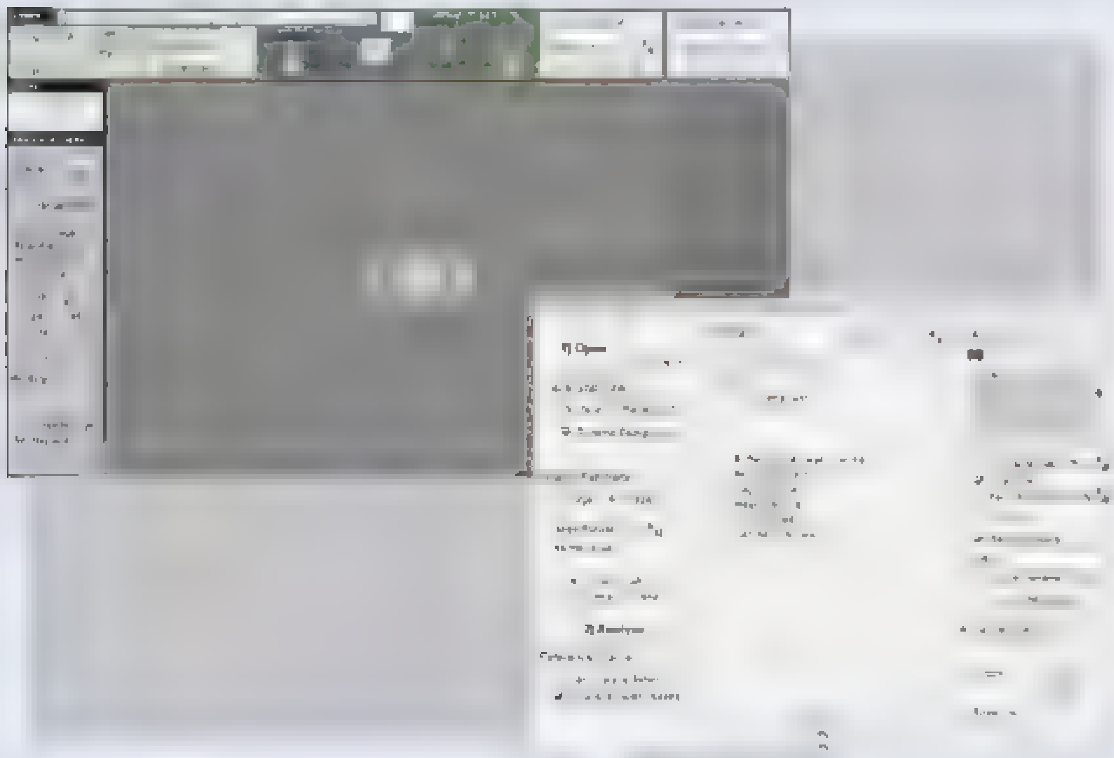


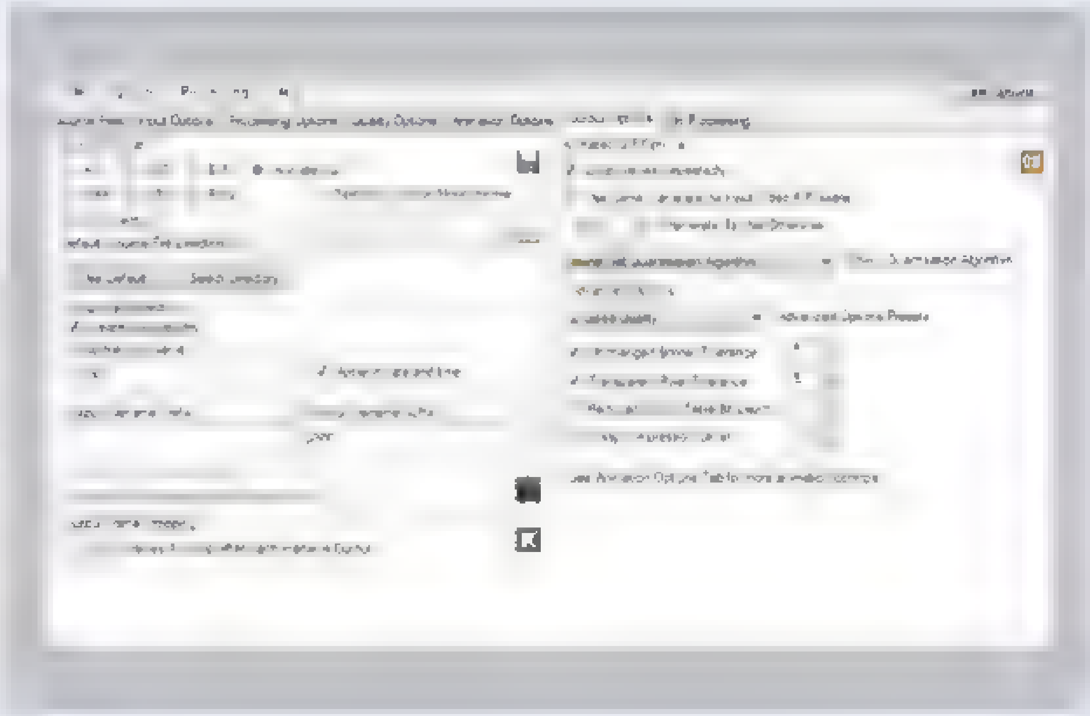
STEP 3

For a one shot colour camera, an atmospheric dispersion corrector (ADC) is useful. An ADC's application needs special attention, so refer to a manual. If you don't have one, the planet and the moons will not appear sharp when imaged, a slight colour fringing appearing due to the atmosphere's dispersion properties.

STEP 4

On a mono camera, a red or infrared pass filter helps stabilise seeing and reduce effects of atmospheric dispersion. Use a zero gamma filter. A 50 70% gain will allow a reasonable frame rate. Unlike normal planetary imaging, you'll need exposures in the seconds range. An app with moon positions will help with locations.





STEP 5

Once you're sure you have the right settings, attempt to capture a sequence of frames. Try to restrict the overall capture time to 1 2 minutes or the inner moons may show a small amount of motion. Make captures every 10 15 minutes. Process each one with a registration stacking program like AutoStakkert! or RegiStax.

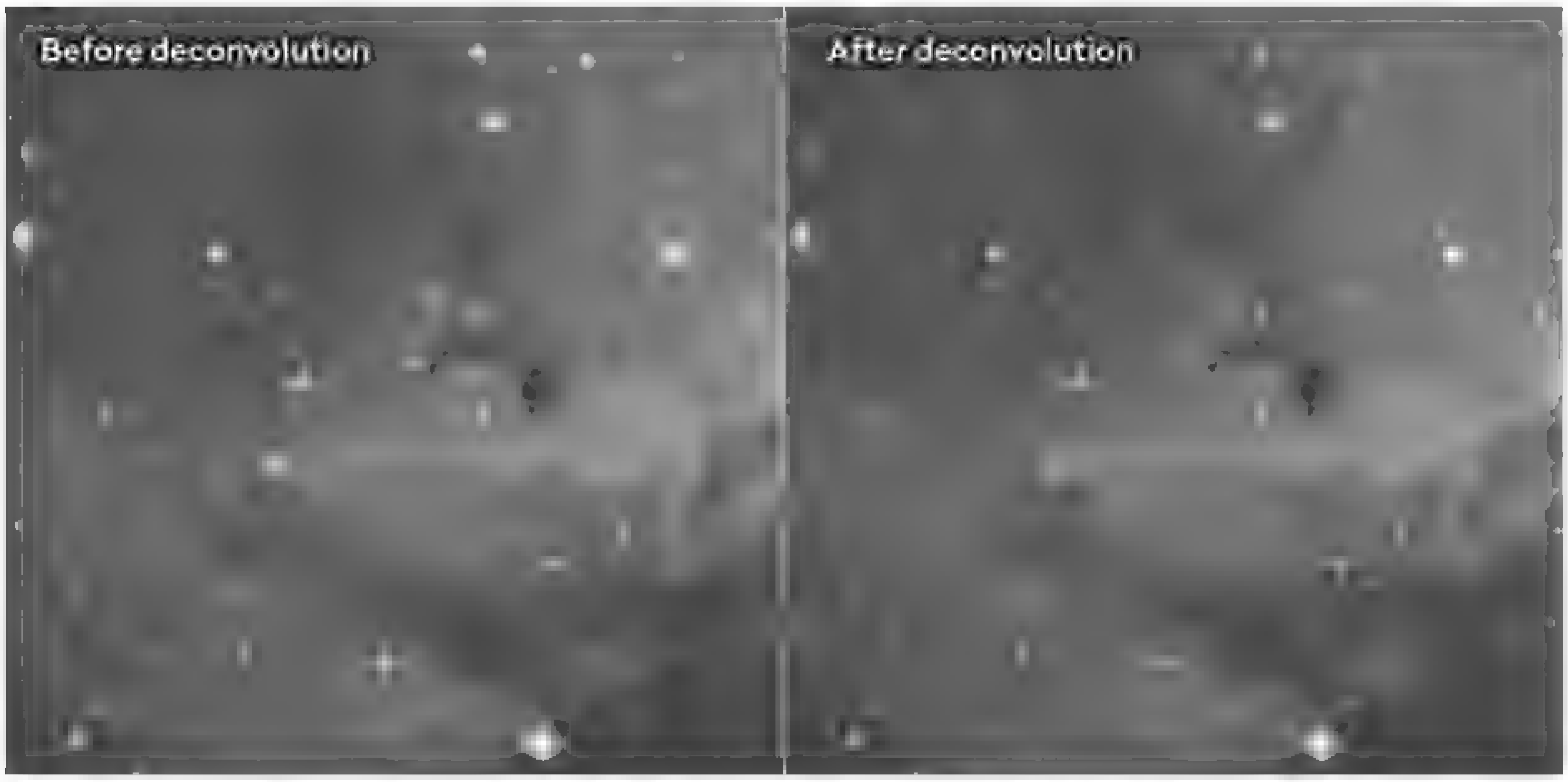
STEP 6

Using your planet moon images, load them into a layer based editor and align each image relative to the planet. Crop so there are no edge gaps. If your editor has an animation option, set it so you can cycle through each image. If not, save each image with a sequence number and animate using a tool such as PIPP.

ASTROPHOTOGRAPHY PROCESSING

Using PixInsight to get rid of atmospheric blur

How the process of 'deconvolution' restores original detail to an image



▲ A close-up image before (left) and after (right) original detail has been restored

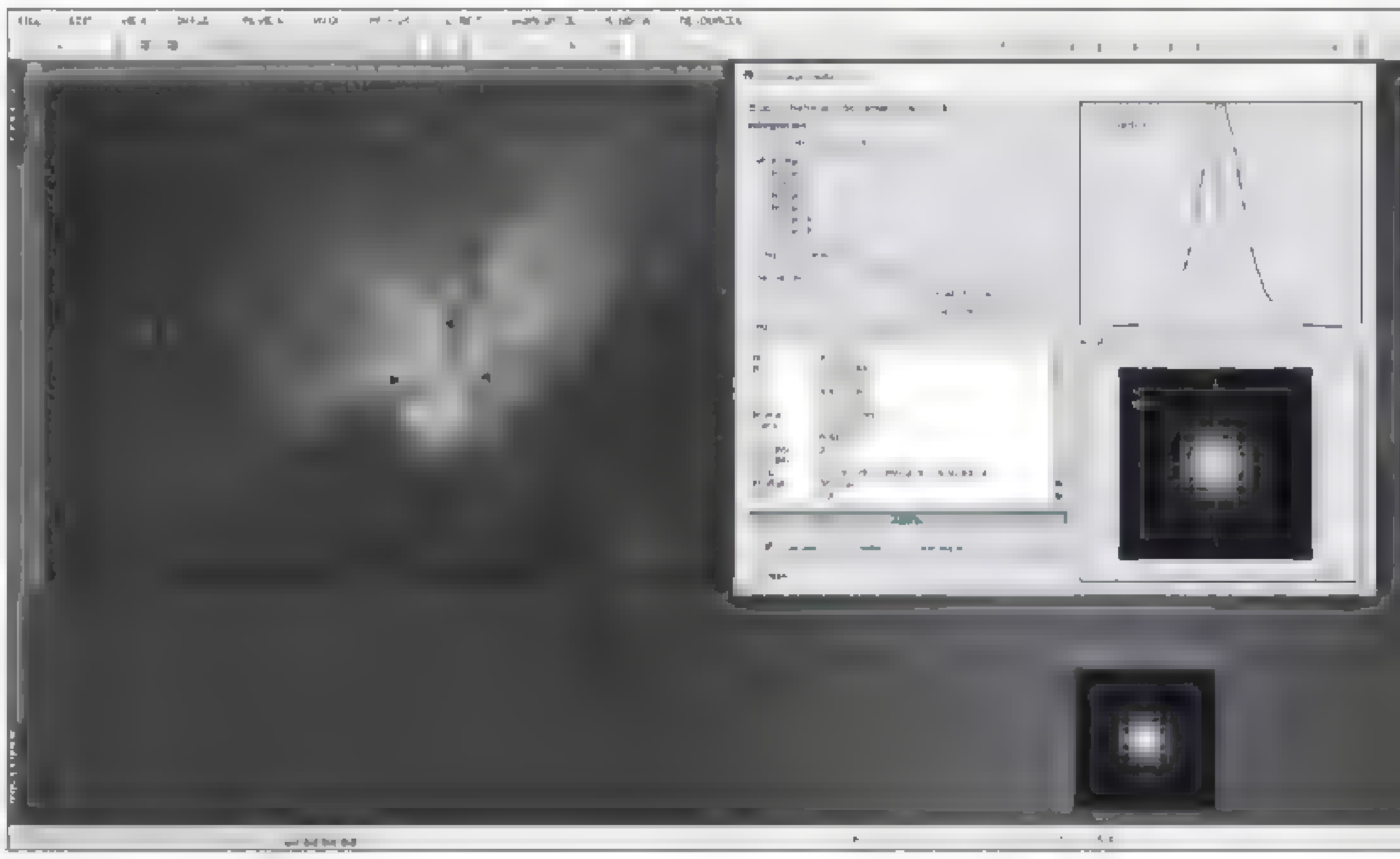
Previously we showed you how to calibrate your images to remove unwanted artefacts (April issue) and how to align and stack them into a single image (June issue). Here we look at undoing the damage caused by Earth's atmosphere.

Despite your best endeavours to achieve excellent focus, atmospheric conditions like seeing and high atmosphere water vapour conspire to blur your image data. Luckily, the original failure of the Hubble Space Telescope to achieve focus prompted a special kind of image restoration software called 'deconvolution' to be developed, which could recover the original detail in a blurred image by analysing the blur. Deconvolution software requires three important pieces of information; a model of the blur's formation known as a 'point spread function' (PSF), a model of the noise level, and an indication of the average image background level. With this information, the software can make a best guess at how to correct blurring.

Deconvolution shouldn't be carried out directly on one shot colour (OSC) images as this will lead to some strange artefacts. Instead, produce a false greyscale luminance copy of your OSC data and deconvolve that; then apply this as a luminance channel to produce an LRGB (Luminance Red Green and Blue) image. For LRGB images produced using a mono camera, just deconvolve the Luminance channel

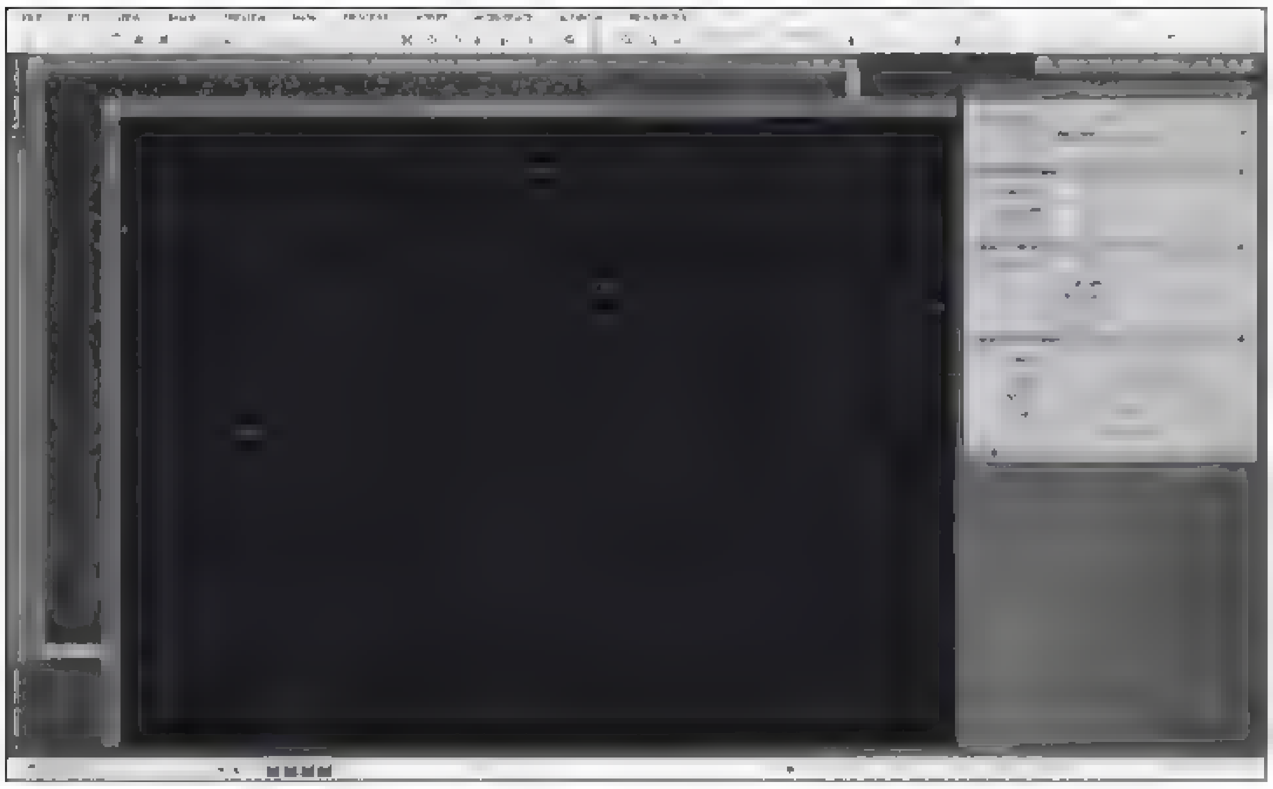
Making masks

PixInsight's deconvolution process works best when you use a synthesised PSF model, generated by selecting Script > Render > PSFImage. Place a tick against Moffat set Sensitivity and Amplitude maximum to 1.00 Amplitude minimum to 0.1 and Max N to 50, then click on the 'Evaluate' button. This will cause the script to evaluate the PSF based on a sampling of up to 50 stars. Click on the 'Create' button to generate the synthesised PSF image. Once you have generated the PSF model you can produce two protective masks; a star mask for

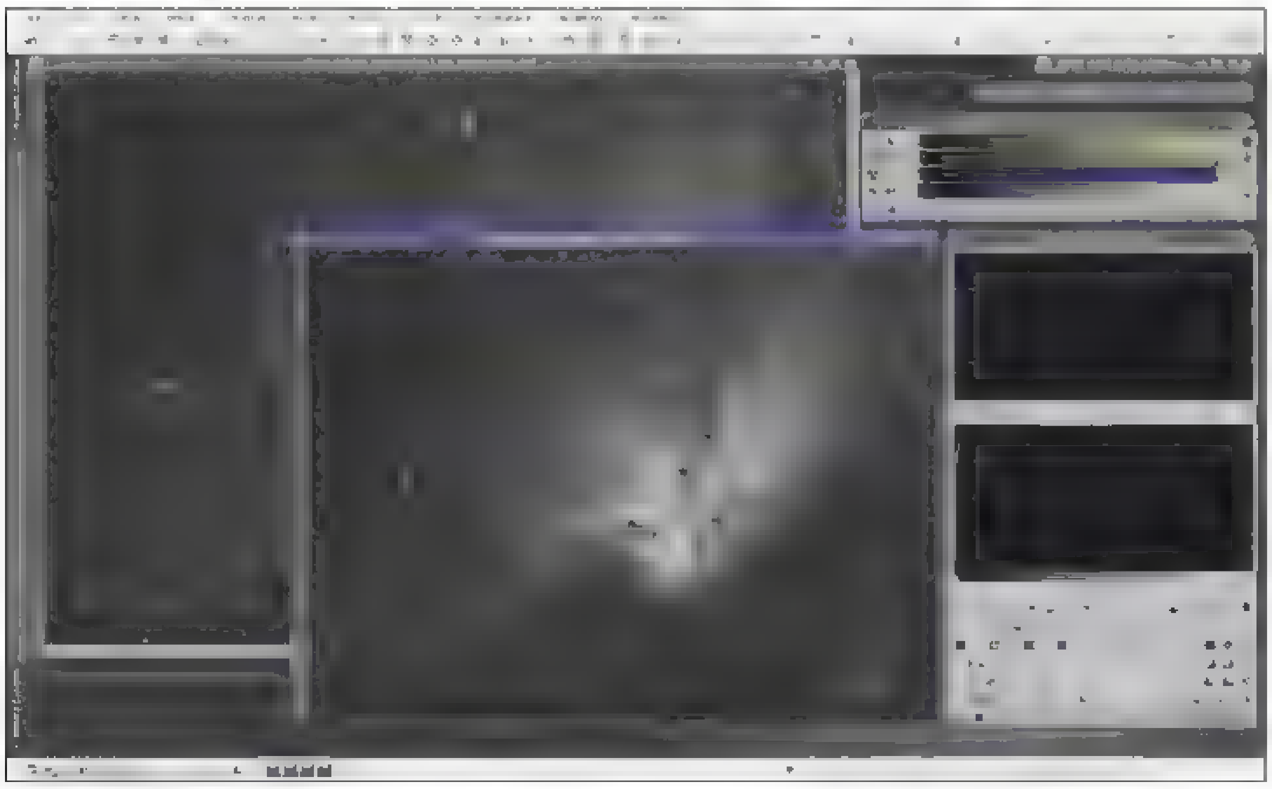


▲ The PSFImage script will evaluate the PSF based on a sampling of up to 50 stars

AL PICTURES: STEVE RICHARDS



▲ **Use a star mask to protect the larger stars during deconvolution**



▲ **A luminance mask protects the background during the process**

larger stars and a luminance mask for the background.

To produce a star mask, select – Process › MaskGeneration › StarMask. Set Noise Threshold to 0.02, set Scale to 6 to target the larger stars, set Structure Growth Large Scale to 2, set Structure Growth Small Scale to 3, set Structure Compensation to 2 and set Mask Generation Smoothness to 16 to achieve a good feather around stars. Drag the 'New Instance' button onto your image. Rename the mask 'Deringing_Mask' by double-clicking on the mask image's tab, shade the star mask, move it to the side out of the way then close the StarMask process.

To produce a luminance mask, drag the image name tab onto the image itself to produce a clone. Select the ScreenTransferFunction (STF) process – Process › IntensityTransformations › ScreenTransferFunction. Click on the 'Auto' button to capture the screen stretch and then select the HistogramTransformation (HT) process – Process › IntensityTransformations › HistogramTransformation. Drag the STF 'New Instance' button onto the base margin of the HT box to set the current stretch, then close STF. Drag the HT 'New Instance' button onto the clone image to fix the stretch on the clone. Next, select the 'Realtime Preview' button and use the HT sliders to darken the background and protect it while leaving the brighter regions light, then fix the new stretch on the clone by dragging the 'New Instance' button onto the clone image and close HT. Rename the clone image 'Luminance_Mask' by double clicking on the images tab, shade the luminance mask, move it to the side out of the way, then close the HT process. Next, select Process › Deconvolution › Deconvolution. Select the External PSF option and choose the PSF image generated by the PSFImage script above. Set the Algorithm to Regularized Richardson-Lucy and Iterations to 25-50.

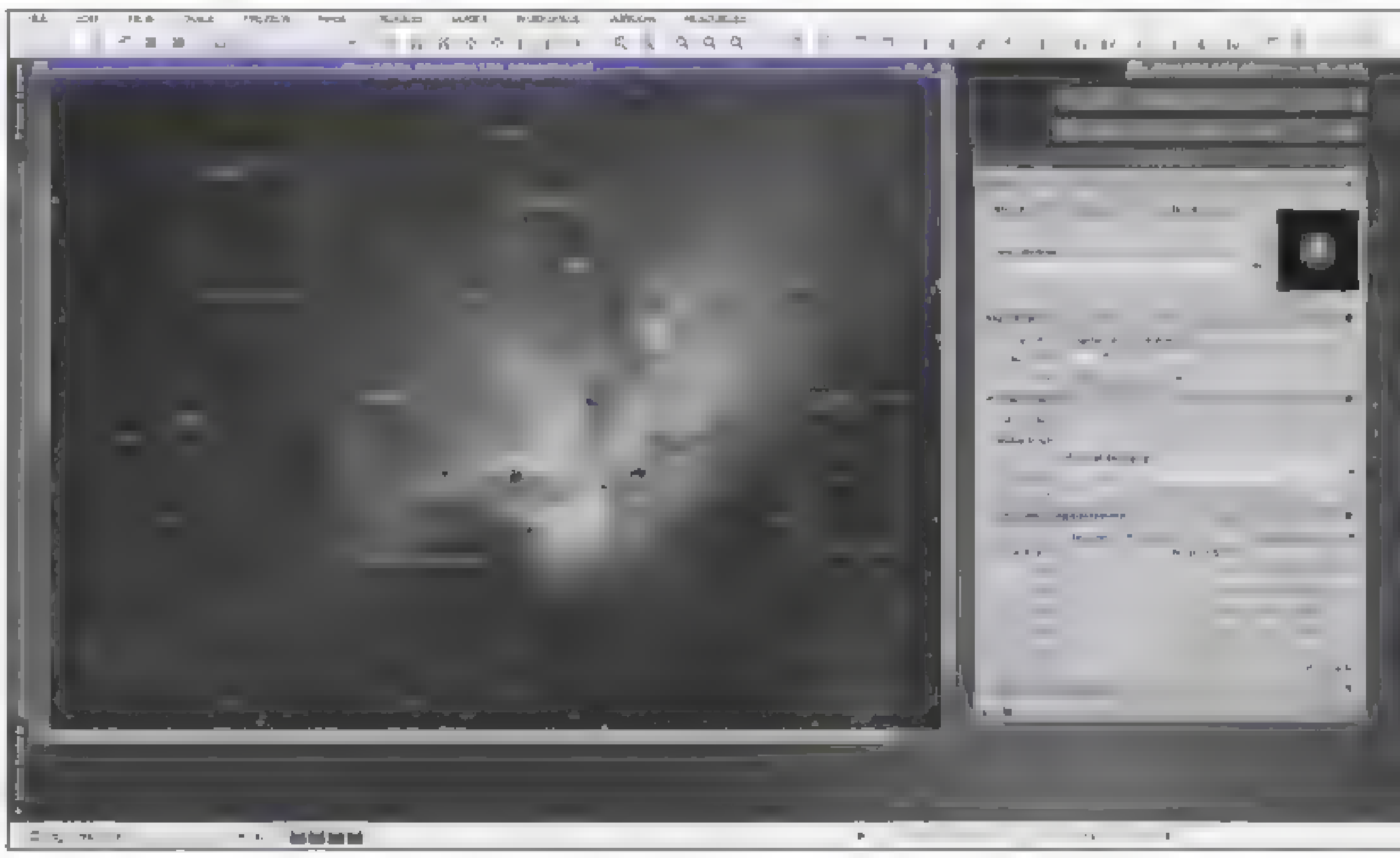
Finishing touches

Using the 'Alt N' key combination produce several screen previews of small areas around the image with some small to medium stars within each and some of the main object. In the Deringing section, set Global dark to 0.0010, Global bright to 0.0000, place a tick in Local deringing and set the Local support to Deringing_Mask. Drag the Luminance_Mask tab onto the left margin of the main image to apply the mask and select Mask › Show mask.

Select the first of the previews, set it to 200% then apply the deconvolution by dragging the 'New Instance' button onto the first preview image. Adjust the Global dark value as required to achieve smaller stars but no ringing. Test on the other previews to ensure that no unwanted artefacts are being generated either around the stars or within the main object. When you are happy that all previews are deconvolving correctly, close them all by right clicking on the preview image tab and selecting 'Delete'. Drag the Deconvolution 'New Instance' button onto the main image to apply the deconvolution.

Steve Richards writes our Scope Doctor column, is an astro imager and author of *Making Every Photon Count: A Beginner's Guide to Deep Sky Astrophotography*

▼ **Screen test: a set of preview selections in the deconvolution process**



Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More ONLINE
A gallery containing these and more of your images

PHOTO OF THE MONTH

△ The Orion Nebula

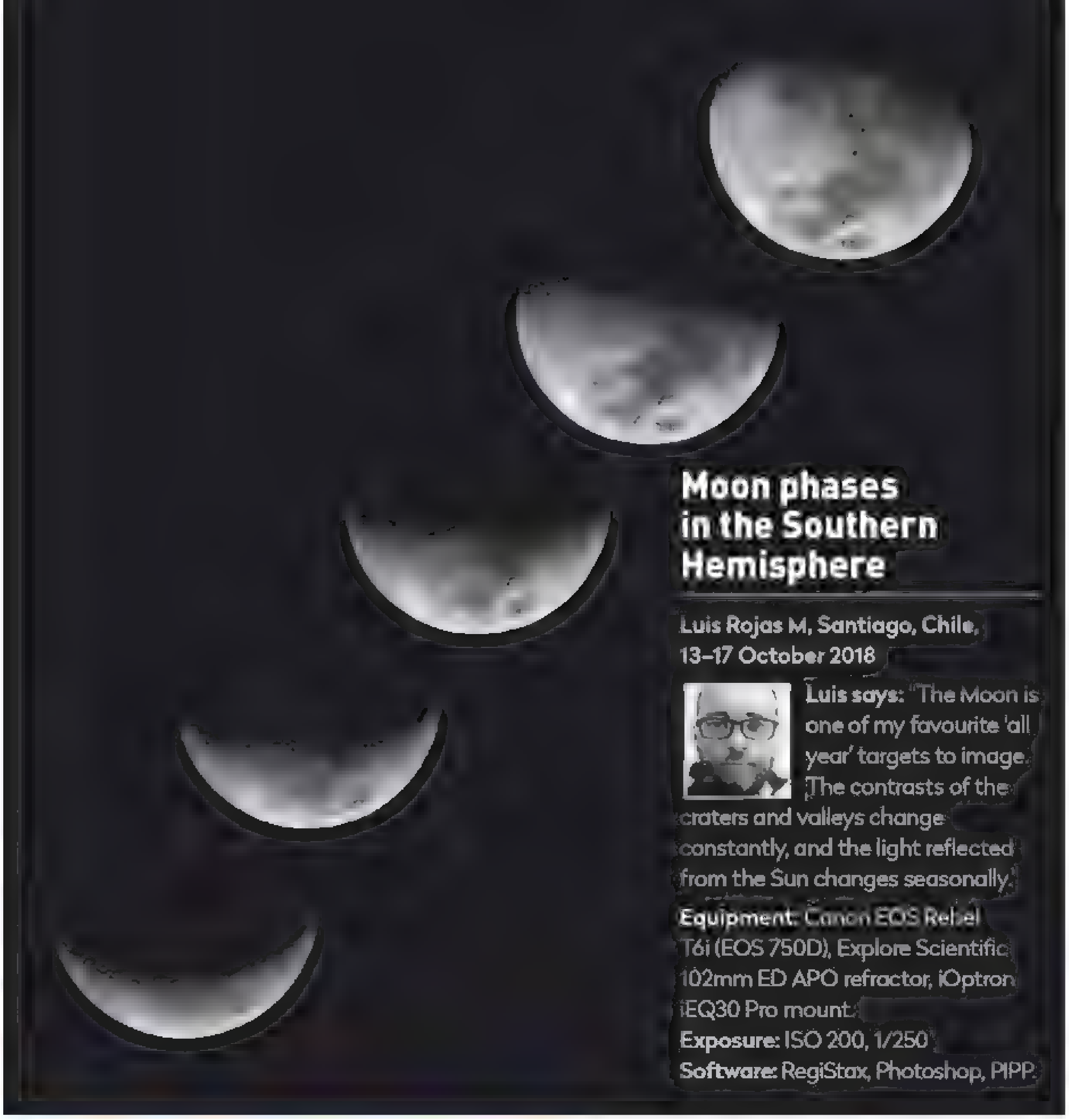
Alberto Ibanez, Castillo de Villamelefa, Barcelona, Spain, 27–30 December 2018, 2–10 January 2019

Alberto says: "The Orion Nebula is a well-known target for any astrophotographer. It's bright, wide and beautiful. I've imaged it many times but have never achieved the depth that I expected. It's a difficult target that pushes the equipment to its limits because of its huge dynamic range. It's almost impossible to render it well without using HDR techniques. I started astrophotography in 2004, but in 2010 I had to give up and returned in 2017. I learned new techniques and updated my equipment and I considered that this nebula would be the best to test to check my improvements. My project's goal was to go as deep as possible."

Equipment QHYCCD 163M camera, Borg 101ED f/4 refractor, Sky-Watcher HEQ5 with Rowan upgrade mount.
Exposure 214x300", 50x120", 98x60", 82x10", 45x5", 49x1" Hα; 613x60", 50x5", 50x1" L; 132x60", 48x5", 48x1" R; 133x60", 50x5", 50x1" G; 118x60", 49x5",50x1" B

Software: Sequence Generator Pro, PHD2, EQMOD, Stellarium, PixInsight Core 1.8.

Alberto's top tips: "For a good quality astro image there are two things to consider. One is acquisition. Stay focused on a target and spend the whole season on it if required, to gather enough integration time. The other is processing. Look at how deep your images are and make sure the faint details are visible. Always keep in mind that the background isn't black.



Moon phases in the Southern Hemisphere

Luis Rojas M, Santiago, Chile, 13–17 October 2018

Luis says: "The Moon is one of my favourite 'all year' targets to image. The contrasts of the craters and valleys change constantly, and the light reflected from the Sun changes seasonally."

Equipment: Canon EOS Rebel T6i (EOS 750D), Explore Scientific 102mm ED APO refractor, iOptron iEQ30 Pro mount. **Exposure:** ISO 200, 1/250". **Software:** RegiStax, Photoshop, PIPP.

▽ The North America Nebula

Emil Andronic, Pontarfynach & Bushey, 5 & 18–20 April 2019

Emil says "Capturing this target has been a pleasure and even though the guiding wasn't always the best, shooting wide-field at 135mm focal length is quite forgiving. I am very pleased with the final result and this photo is probably my best HaRGB to date."

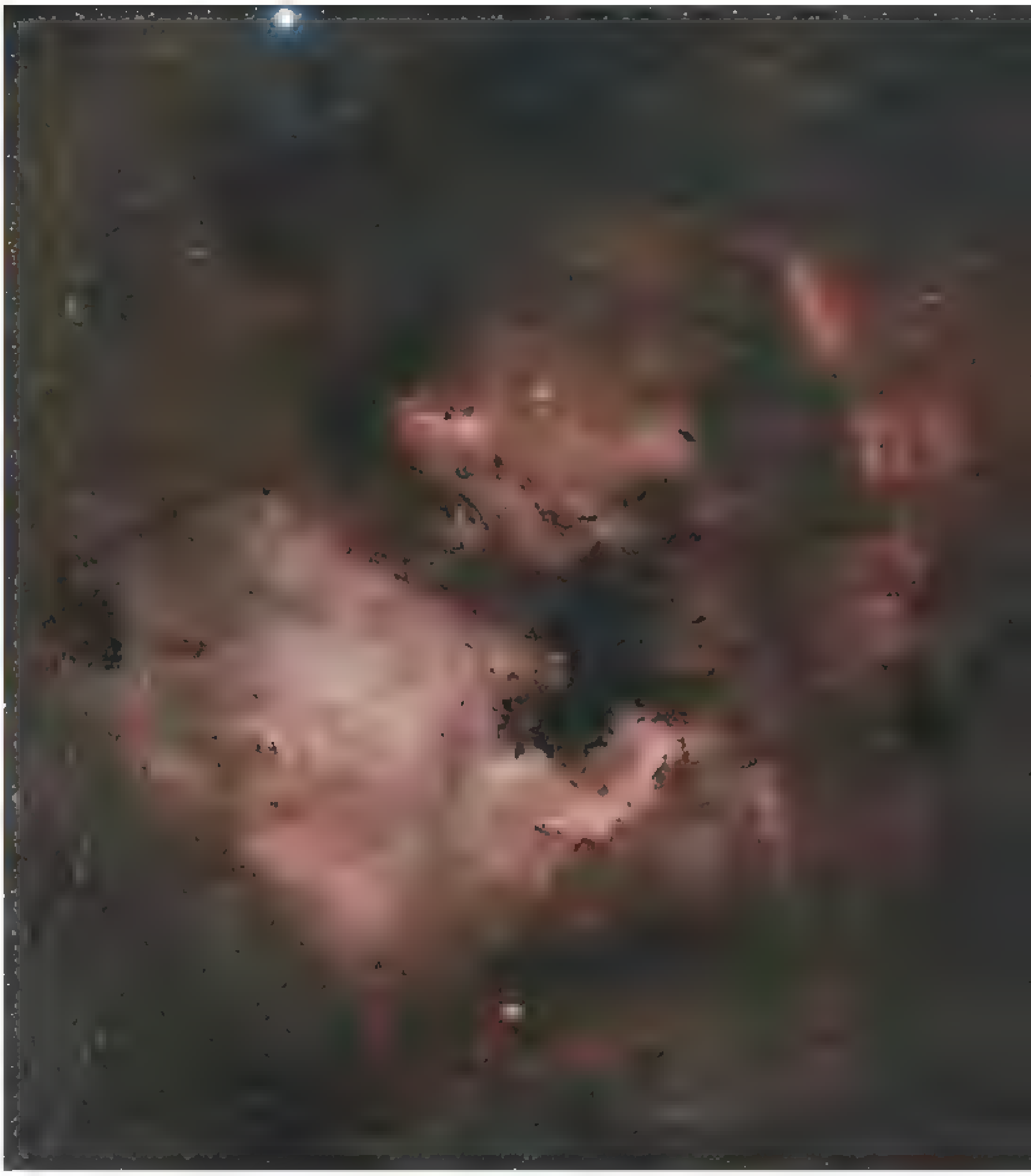
Equipment: Canon EOS 700D DSLR, Samyang 135mm lens, Sky-Watcher EQ3 Go-To mount. **Exposure:** ISO 1600, 71x300" Ha; ISO 800 10x180" RGB. **Software:** Astro Photography Tool, SharpCap, PHD2, Photoshop, Lightroom.

△ Sunspot

Andy Booth, Newark-on-Trent, 14 May 2019

Andy says: "I am new to solar observing and imaging. You never forget your first view of a live solar prominence and magnetic activity surrounding a sunspot. There is a steep learning curve in imaging the Sun, but I am blown away with what can be achieved with modest equipment."

Equipment: Altair Astro GPCAM2 AR0130, Sky-Watcher 102mm guidescope, Sky-Watcher NEQ6 Pro mount. **Exposure:** Best 450 frames of 2,000. **Software:** AutoStakkert!, Image Post Processor, Photoshop.



△ Bright Orion

Andrew Allan, Dunning, Perth and Kinross, 27 February 2019

Andrew says "I had planned to shoot the Milky Way core but the cloud rolled in. I turned my back to see I had been standing in an excellent position for Orion for most of the night and hadn't realised. I am happy at how this turned out, as it wasn't entirely planned, but made the whole trip worth it."

Equipment Canon EOS 1300D DSLR, 18-55mm lens. Exposure: ISO 3200, f/3.5, 25". Software: Lightroom.

ISS Solar Transit ▷

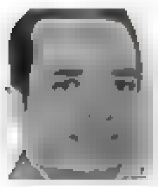
Ian Smith, Whitminster, 29 April 2019

Ian says: "I had always wanted to capture an ISS (International Space Station) solar transit and I had to travel just 8km to get in the centre of the track. Of the 500 video frames taken only one showed the ISS, so I was really lucky."

Equipment ZWO ASI294MC Pro, Altair Wave Series 80mm apo refractor, Sky-Watcher HEQ5 Pro SynScan mount, Baader white light solar film. Exposure: single frame from 500-frame video, 25fps. Software: SharpCap.

▽ NGC6188

Israel Mussi, Goiânia, Brazil, 23–26 May 2019



Israel says: "I wanted to highlight the incredible dark structures of the nebula using SHO filters and I really liked the result. My biggest challenge was to image this target from a city with light pollution between 7 and 8 on the Bortle scale."

Equipment: ZWO ASI 1600mm Pro image camera, Levenhuk Ra 250 Ritchey Chrétien, iOptron CEM120 mount. Exposure: 10h, 54x180" SII, 59x240" Hα; 50x240" OIII. Software: Sequence Generator Pro 3.0, PixInsight, Photoshop.

△ Leo Trio

Ron Brecher, Ontario, Canada, 25 March–8 May 2019

Ron says: "I'm pleased that I was able to take advantage of the brief clear spells this spring to capture this lovely trio. These three galaxies are just the right size for my imaging setup and were particularly well placed in the night sky."

Equipment: QHY 16200-A camera, Sky-Watcher Esprit 150ED apo triplet refractor, Paramount MX mount. Exposure: 60x10', L; 14x10' R, G and B. Software: PixInsight.

ENTER TO WIN A PRIZE. HERE'S HOW:

Whether you're a seasoned astro-photographer or a beginner, we'd love to see your images. Email them to contactus@skyatnightmagazine.com. Ts&Cs: www.immediate.co.uk/terms-and-conditions

We've teamed up with Altair Astro UK to offer the winner of next month's *Gallery* an Altair Astro Planet-Killer 685nm Premium IR Pass Filter with AR coating, designed to deliver sharper lunar and planetary images with mono CCD or CMOS cameras. For more info visit: www.altairastro.com • 01263 731505

ALTAIR ASTRO

The best in equipment, accessories and books each month

REVIEWS

Find out more about how we test equipment at
www.skyatnightmagazine.com/scoring-categories

86

We see if the Zenithstar 126 apo refractor from William Optics matches its looks with performance

WWW.THESCIENCESTUDIO.NET

PLUS: Books about NASA's infrared discoveries, astronomer Mary Evershed, and our recommended accessories

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

William Optics
Zenithstar 126 apo refractor

A stylish looking telescope that offers outstanding views and images

WORDS: TIM JARDINE

VITAL STATS

- **Price** £2,149 ZS126, plus £125 guidescope
- **Optics** f/7.7 apochromatic FPL53 doublet
- **Aperture** 126mm
- **Focal length** 970mm
- **Focuser** 3-inch V-Power dual speed Crayford
- **Extras** Dovetail bar, tube rings, carry handle, Bahtinov mask
- **Weight** 9.94kg
- **Supplier** Widescreen Centre
- **Tel** 01353 776199
- **www.** widescreen-centre.co.uk

The Zenithstar 126mm refractor (ZS126) from William Optics is among the best looking telescopes we have reviewed. With a matching coloured trim throughout, the ZS126 oozes style, but, more importantly, the attention to detail given to styling has also gone into functionality. It boasts an impressive range of practical features.

As refractors go, four-inch models occupy a favourable spot between performance and portability, and the ZS126 is no exception. Despite its solid design, its weight is less than 10kg and, with the large dew shield retracted, it's just 800mm long. The scope has an integrated handle and finderscope rail, which works together with CNC tube rings and a premium Losmandy-style dovetail bar to provide a reliable platform for the instrument. Our review package included an optional 50mm guidescope, which made a beautiful set.

Galaxy quest

With this impressive appearance, we were keen to see how the ZS126 actually performed. The lens is f/7.7, giving a focal length of 970mm, making the scope suited for observing, or astrophotography with an optional field-flattening lens. We didn't have the flattener available but used the first clear sky opportunity to run basic tests with a mono CCD camera and filters. This demonstrated that the doublet lens produced good, sharp, round star images, and that red, green and blue wavelengths came to close focus together. Despite the lack of a flattening lens, there was barely any sign of coma using our Sony 460 size CCD, so we decided to try a few imaging sessions using a one-shot colour version of the camera. Targets like globular clusters were nicely presented at a good scale, and we enjoyed our time imaging M13 and M92 in Hercules. The Whirlpool Galaxy, M51, showed what the scope was capable of on galaxies, and we were impressed that the four small but more noticeable stars within the Ring Nebula, M57, were present and sharp. For imaging, the ZS126 has great potential. ▸

True colours

Described as synthetic fluorite, the air spaced apochromatic double lens in the ZS126 is produced using FPL53 glass, developed for its low refractive index while avoiding the issues inherent with natural fluorite lenses. This means the scope can offer views that are free of chromatic aberrations, usually seen as garish colour fringes, especially on bright targets like the Moon and planets. Because the colour is controlled by bringing all wavelengths to focus together, the overall view is enhanced, and is typically sharper than comparable size scopes with cheaper lenses. When used for taking photos, the practical benefit is that bright stars do not produce unwanted coloured haloes, and overall colour rendition is better, making an apochromatic telescope like the ZS126 an ideal match for DSLR and one shot colour CCD cameras.

Lens coatings are important to improve contrast and reduce unwanted reflections and glare, while minimising light loss. The Zenithstar has a reassuring green tinge to the lens, and the cell is stamped 'SMC' in reference to the coatings applied.

Matching guidescope

A 50mm guidescope is included in this package, complete with matching rings and easy to use 1.25-inch Rotolock clamp. Fittings are provided to mount this smaller tube onto the main telescope carry handle. The downloadable manual explains how a separate finderscope can be fitted either side of the focuser.

Internal baffles and dew shield

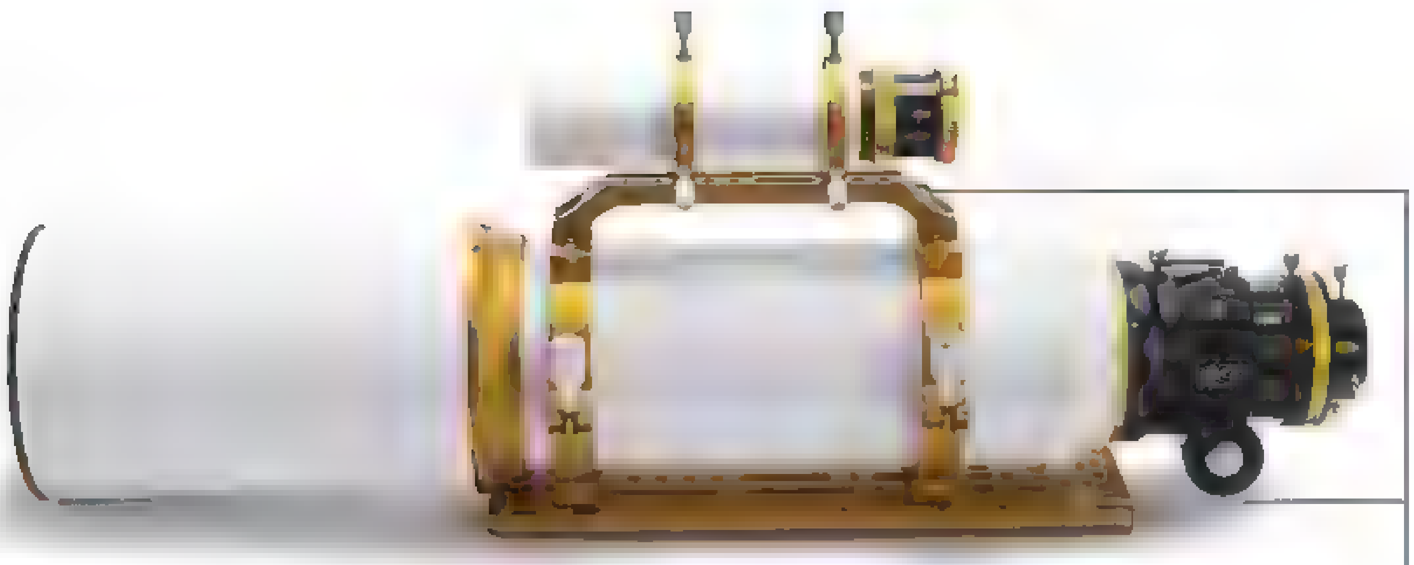
Inside the telescope tube, graduated baffles reduce stray light and increase contrast, while the substantial, well-fitting dew shield extends a healthy 200mm past the objective lens, protecting it from incidental light intrusion and helping to reduce the likelihood of dew problems. The dew shield locks in place with a plastic-tipped screw.

Focuser

The newly designed 3-inch Crayford focuser is 360° rotatable with a separate facility for rotating the camera or diagonal. The drawtube is graduated with imperial and metric measurements for quick rough focusing. Fine focus controls working at 1:10 are extremely smooth, and the focuser has a full 10cm of travel.

Integrated Bahtinov mask

The front of the lens cap unscrews to reveal an integrated Bahtinov focusing mask, ideal for achieving perfect focus whether observing or imaging. Strong design and precision machining make this a practical and useful addition, although the large diameter screw cap proved a little tricky for smaller hands to undo.



Dovetail bar, tube rings and carry handle

Exquisitely machined and finished, the 40x10cm Losmandy-style dovetail bar supports custom-matching tube rings with a bolt-on carry handle–guidescope rail. A large number of auxiliary holes and fittings and extra bolts allow for inclusion of other accessories.

KIT TO ADD
1. William Optics 2-inch Dura Bright diagonal with carbon fibre plates
2. William Optics 3.5- to 2-inch Rotolock adaptor
3. William Optics SWAN 40mm 2-inch eyepiece with 72° apparent field

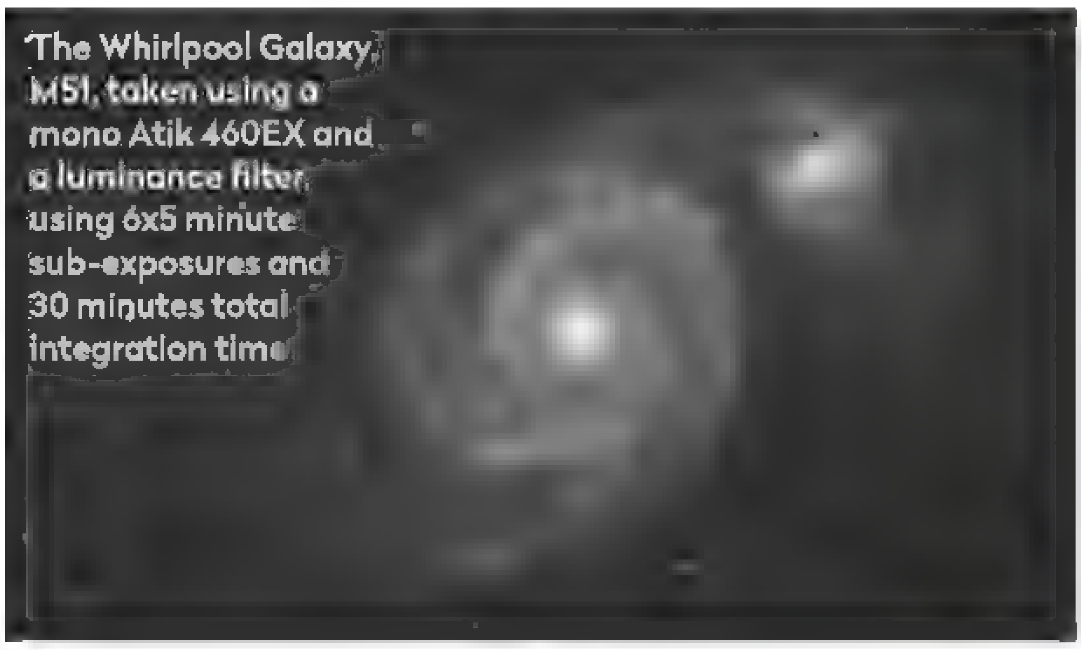
▸ Precise focusing, a pre-requisite for good results, is accomplished by a Crayford focuser. We found that this was highly adjustable, and held the weight of our equipment without slopping, or the image shifting when locked. The large controls had a bit of a new feel about them, and the action was a bit sticky at first, but fine focus control was exceptional, and combined with the integrated Bahtinov mask made focusing the scope a swift, simple affair. It is worth noting that the short tube design which aids portability, also means that extension tubes are needed when using a camera, and in fact, we also had to use a short extension tube with our 2-inch diagonal to focus with some of our eyepieces.

With a dominant Moon, we started using the scope for visual observations. The Moon itself demonstrated the apochromatic nature of the objective lens, revealing a crisp, clear image with no discernible colour aberrations on the brightest lunar edge during steadier seeing patches. A quite enchanting, wide sky view with sharp stars right to the edge of our 21mm, 100° eyepiece (at 47x magnification) made us wish the nights were longer and darker, while our 10mm eyepiece produced a practical 97x magnification, allowing the wide, multi-coated objective lens to bring in views of M51, despite challenging skies at our site. Double star enthusiasts would no doubt enjoy the views we experienced of Epsilon Lyrae, a good, easy split of the stars with perfect diffraction patterns. During one observing session the seeing and transparency improved to the point where we were able to use a 2x Barlow lens with our 4.5mm eyepiece, giving magnification of 430x, and even to double it again with another 2x Barlow, to 860x. These extreme magnifications, though rarely practical, did demonstrate good, round airy disc patterns, revealing the quality of the lenses and lens cell in the ZS126.

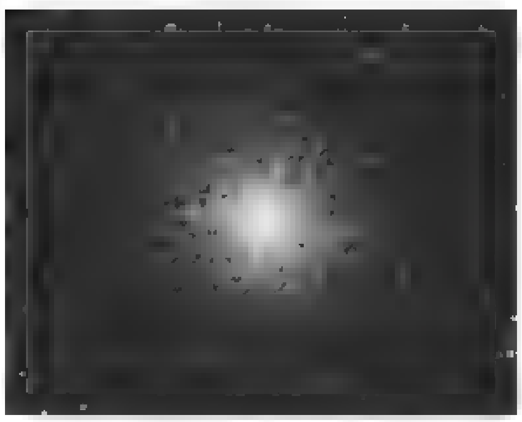
Producing images and views as outstanding as its own appearance, the Williams Optics ZS126 looks set to become a favourite among observers and astrophotographers alike.

VERDICT

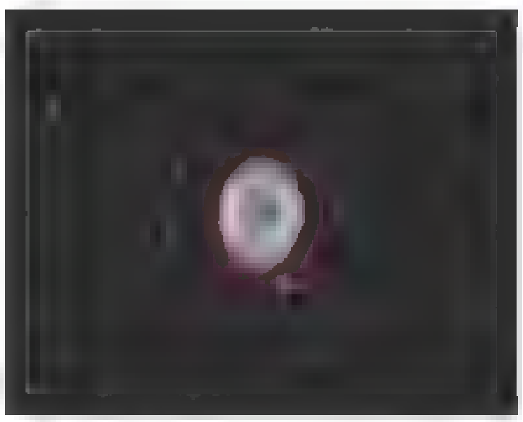
Build and design	★★★★★
Ease of use	★★★★½
Features	★★★★½
Imaging quality	★★★★½
Optics	★★★★★
OVERALL	★★★★½



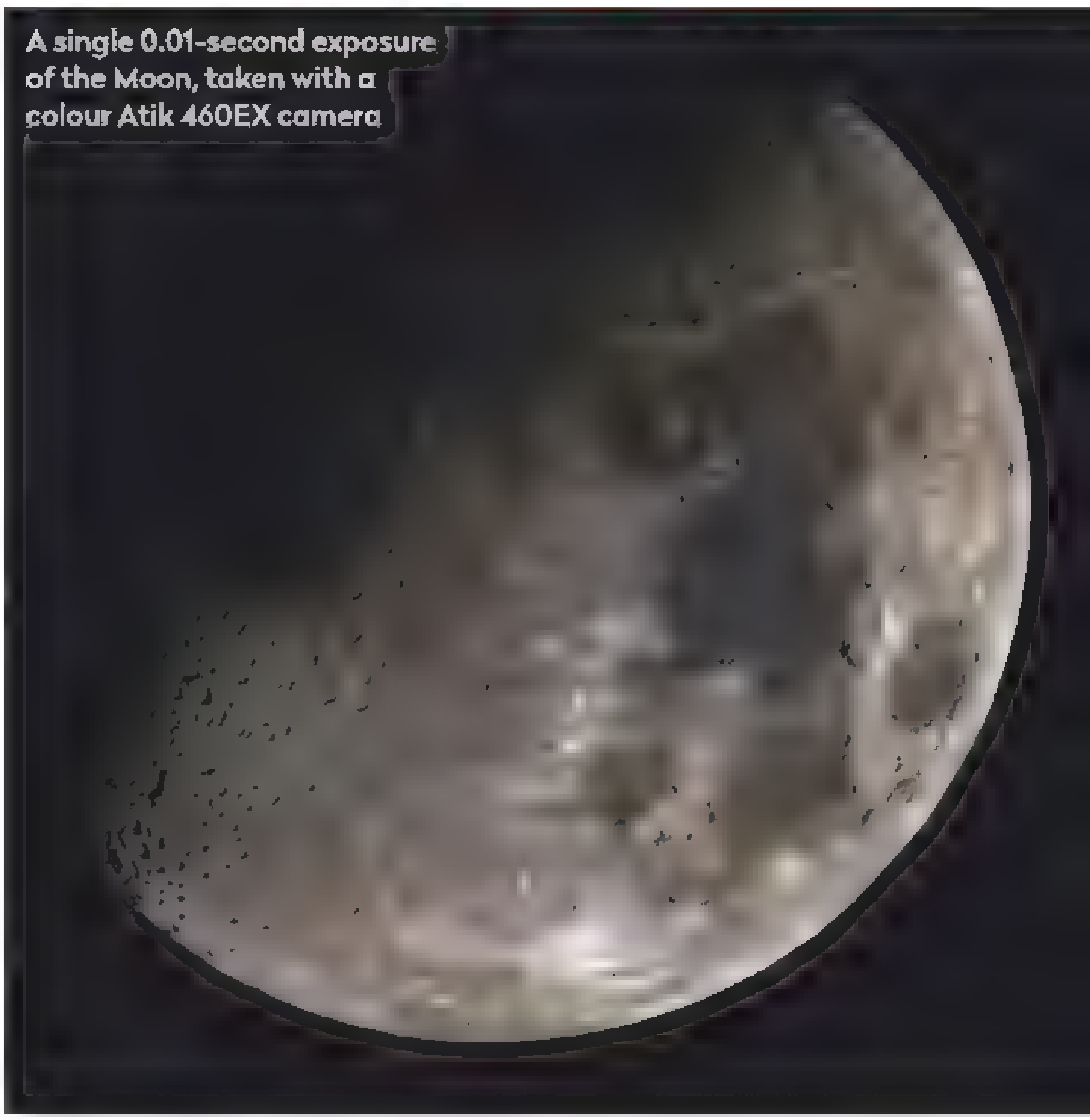
The Whirlpool Galaxy, M51, taken using a mono Atik 460EX and a luminance filter, using 6x5 minute sub-exposures and 30 minutes total integration time



▲ M13, taken on a colour Atik 460EX camera, with 18x10 minute sub-exposures and three hours total integration time



▲ M57, taken on a colour Atik 460EX, with 20x10 minute sub-exposures and three hours 20 minutes total integration time



A single 0.01-second exposure of the Moon, taken with a colour Atik 460EX camera

WWW.THESECRETSTUDIO.NET, TIM JARDINE X 4

Our experts tell you what they think of the latest kit

FIRST LIGHT

iOptron CEM40 centre-balanced equatorial mount

A compact platform with impressive load bearing and accuracy

WORDS: TIM JARDINE

VITAL STATS

- **Price** £1,445 (including VAT)
- **Type** Centre-balanced equatorial mount (CEM)
- **Load capacity** 18kg
- **Autoguiding** Integrated ST4 port
- **Tripod** Stainless steel, 110cm maximum height
- **Weight** 7.2kg
- **Power** 12V 5A (mains power supply included)
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.**altairastro.com

The iOptron CEM40 (centre-balanced equatorial mount) is an unusual design. If you're used to looking at 'traditional' German equatorial mounts (GEMs) the CEM can initially be quite perplexing. In the CEM design, the declination axis is offset to the lower end of the RA (right ascension) shaft, on the opposite end to the counterweight. This shifts the load's centre of gravity onto the RA axis so that it sits centrally on the shaft rather than at one end, as would be the case with a traditional GEM, offering a number of advantages (see 'Style with substance' box).

At a little over 635kg the CEM40 is an interesting prospect. With features normally found on high-end mounts, it also maintains a strong foothold in the portable grab-and-go arena. It has an impressive 18kg load capacity (for comparison a Celestron C11 optical tube weighs 12.5kg), free-running lockable clutches, permanent periodic error correction, GPS and a semi-automatic electronic polar-alignment system. It doesn't skimp on quality: the mount body is solidly constructed from CNC machined aluminium. We were also impressed with the quality of the online electronic documentation provided for this mount. It took us through the initial setup procedures in a well-organised, logical step-by-step fashion.

Testing alignments

The iPolar electronic polar alignment system recognises stars around your local celestial pole but doesn't need to be able to see the pole itself; a useful option if visibility is limited. On our first outing, our rough polar alignment was too rough and the star recognition system failed due to the pole being outside the image frame. After realising what we'd done, we moved the mount into a better position. Although we assumed we would have to initiate another match attempt ourselves, the recognition software had kept watching and reported a match. ▸

Style with substance

The CEM40's shape is distinctive and unusual. A conventional German equatorial mount places the declination axis at one end of the RA shaft, carrying both the mass of the counterweights and scope. In the CEM design, the declination axis is staggered so the counterweights remain at one end of the RA axis with the scope sitting at the other. This design balances the RA axis, placing its centre of gravity directly over the tripod or pier. The lack of bias to one side of the RA shaft helps improve stability. It also makes fine adjustment of the mount's altitude, used when fine-tuning the polar alignment, easy.

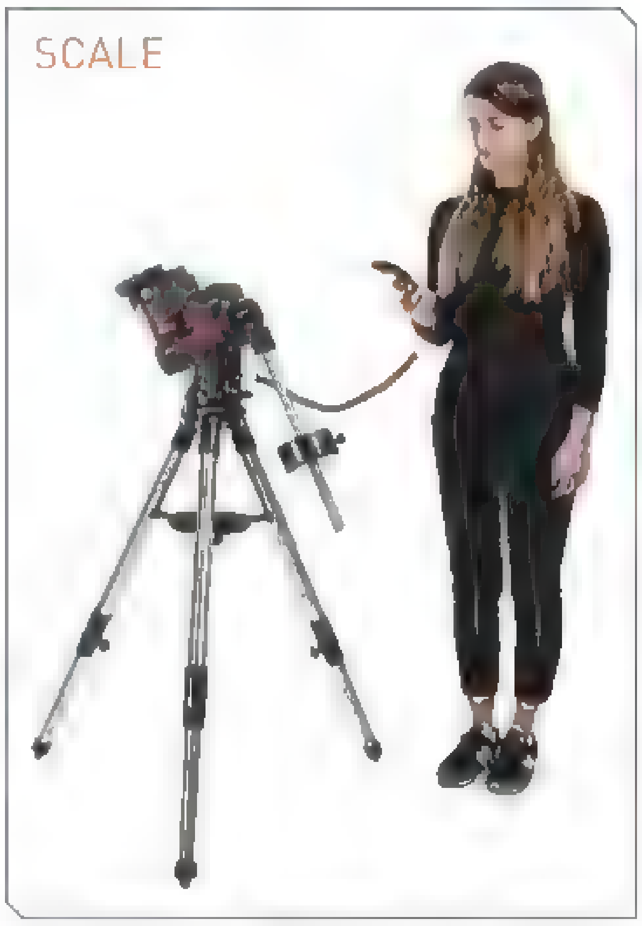
The CEM40 is designed to operate from the equator to 60° of latitude. It achieves this by providing two latitude ranges of 0–35° and 25–60°. A straightforward mechanical procedure is required to select your desired range before initial operation. The CEM40 operates via high-resolution stepper motors capable of 0.08 arcsecond movement steps combined with 110mm, 216 teeth RA and dec. gears. Slew rates can be set from sidereal to 4.5° per second.

ALL PICTURES: WWW.THESECRETSTUDIO.NET

Cable management

A cable management plate on the dovetail clamp offers a USB 2.0 (but no USB 3.0) type-A connector, 12V DC (3A maximum current) and an ST4-compatible autoguider port. It's used to maintain tidy connections to mounted equipment and can be moved to the other end of the clamp assembly if required.

SCALE



Go2Nova handset

The mount is natively controlled by a Go2Nova 8407+ hand controller. This presents a number pad, four direction arrows, menu, back and enter buttons. Its LCD screen is heated to permit operation in temperatures as low as –20°C and has a generous 8x21 character display which we found was well utilised.

iPolar electronic polarscope

Accurate polar alignment is performed via an in-built iPolar electronic polarscope. A dedicated USB port is provided for connection to your computer or laptop running the iPolar software. Once connected to the scope, the software is able to detect and identify the stars around your local celestial pole, indicating how to adjust the mount for accurate polar alignment.

KIT TO ADD
1. iPolar software
2. Altair 102 ED triplet apo refractor
3. Altair Hypercam 183C Pro colour astronomy camera

▸ The software places a cross and circle on your laptop's screen, typically misaligned. Adjusting the mount's altitude-azimuth position is required to get both shapes to line up. A couple of hex bolts need loosening to do this and a magnetically clipped hex key is kept on the mount. The software zooms in on the cross and circle when alignment gets close.

A 32-channel GPS dongle is provided, supplying location, date and time information automatically. Once polar alignment has been achieved, it's a simple process to run a one-, two- or three-star alignment to refine the mount's pointing model.

We selected numerous targets. With a camera attached to a 1,000mm focal length scope, we instructed the mount to slew to each target and took an image. The object was fairly well centred each time.

Taking control

The CEM40 can be controlled via an optional Wi-Fi dongle, a USB connection to a computer running the Ascom platform, or via the Go2Nova 8407+ hand controller. The GoToNova Go-To system has a databse of 212,000 objects, all accessible via this controller.

Native mount periodic error is quoted at +/-7 arcseconds. We were able to set up the CEM40 in a couple of minutes with the ability for precise Go-To and excellent unguided tracking, achieving exposures at 1,000mm focal length of 2, 3 and 4 minutes without noticeable star elongation. For extended exposure, the CEM40 provides an ST4-compatible guide port for autoguiding functionality. This is where the 18kg-load capacity is important, allowing for a substantial guidescope to be fitted to the main imaging scope.

Overall, we were impressed with the CEM40. It's well designed and offers substantial functionality. It's stable even with heavy loads, relatively quiet in operation and is ideal if you need to move location to get under dark skies. Its excellent Go-To and tracking precision also make it an exciting prospect for astrophotography. Overall, it's a great investment for both beginners and experienced astronomers alike.

VERDICT

Assembly	★★★★
Build and design	★★★★
Ease of use	★★★★½
Go-To accuracy	★★★★½
Stability	★★★★½
OVERALL	★★★★½

Self-centring dovetail clamp

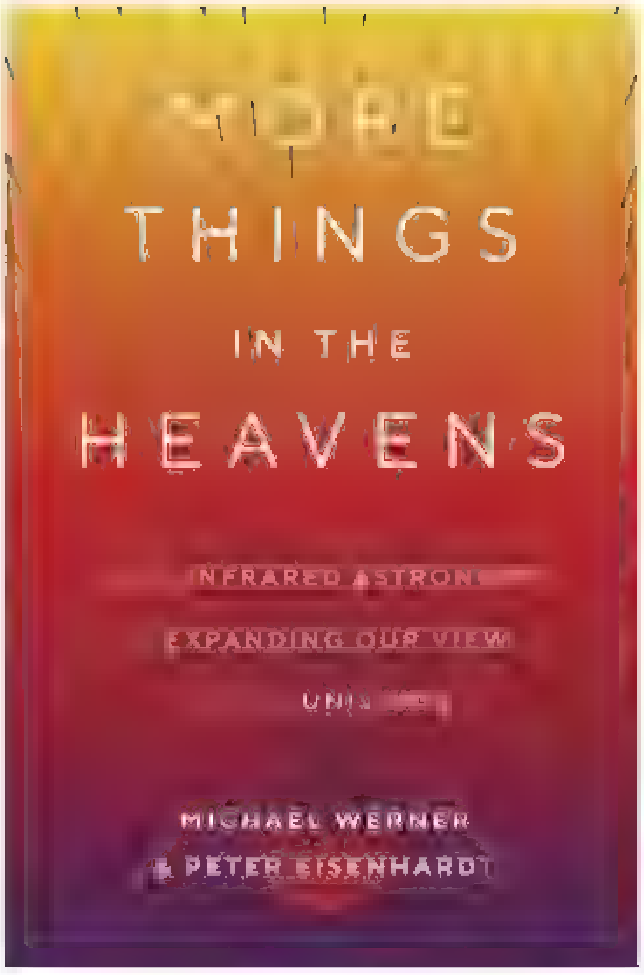
The CEM40's supplied 5-inch iOptron Universal Saddle can accommodate Vixen or Losmandy-D sized dovetails. A small mechanical procedure is required to set the clamp for the appropriate dovetail type. The position of a fixed block – which the clamp locks the dovetail against – can be adjusted to ensure perfect dovetail rail-centring.

Free-running bearings

The CEM40 has free-running bearings. When an axis clutch is disengaged, it's able to rotate freely without significant resistance. If you keep hold of your scope when first disengaging the clutches, this allows you to fine tune your equipment's balance. Once achieved, clutch switches re-engage each axis to its drive system.

New Apollo 11 anniversary titles reviewed

BOOKS



More Things in the Heavens

Michael Werner & Peter Eisenhardt
Princeton University Press
£27 ● PB

The Spitzer Space Telescope is one of NASA's 'Great Observatories' and has certainly earned the name after over 15 years in space. *More Things in the Heavens* is a book written by two key members of the science team who've been involved for three decades.

The book comprises a tour through some of Spitzer's science highlights, though, as the preface states, it is very much the tip of the iceberg in terms of the results. While most books move outwards through space, this book follows Spitzer's science objectives. After explaining the motivation for infrared astronomy, first up is its work on the formation and evolution of stars and planetary systems, including the impressive data on exoplanets. Then we come closer to home and our own Solar System. Next, we explore the results from our own Milky Way, followed by nearby galaxies and finally some of the most distant galaxies known.

Although this book isn't suitable for someone who's uncomfortable with graphs and scientific figures, it's certainly not an academic publication and it contains a number of the amazing images from Spitzer. While it does use many images and graphs from the large library of references, many of them have been adapted to make them more suitable for a broader audience. This also gives some welcome aesthetic consistency, with a bold, colourful style throughout the book.

For those who want to delve deeper, there are appendices with details of the history and technology of the mission and a thorough list of notes and further reading. What we don't get is much of the authors' personal perspectives, with the focus being on the broader group of people doing the research. As it is, there's a fascinating insight into how the scientific process of discovery works, putting the results made by the huge team using Spitzer in context with the wider research field. If you're studying astrophysics or have followed some of the breakthroughs made using Spitzer over the last decade and a half – be that buckyballs in space, new rings around Saturn, or observations of the Galactic centre – then this would be an ideal chance to gain a bit more depth. ★★★★★

▲ Seeing infrared: NASA's Spitzer Space Telescope

NASA/JPL-CALTECH/R. HURT (SSC)

***Dr Chris North** is an Odgen science lecturer and Science & Technologies Facilities Council public engagement fellow at Cardiff University*

Interview with the author
David Chudwin

What does infrared reveal about the Universe that optical light does not?

We used to summarise infrared astronomy as 'the old, the cold, and the dirty'. The old because the cosmic expansion redshifts light from distant objects into the infrared: this is some of the oldest light in the Universe. The cold because in the infrared we can see objects which are too cool to radiate much visible light. The dirty because much of the infrared light that we see is radiated by particles of interstellar and circumstellar dust, and also because dust clouds that are opaque at visible wavelengths may be quite transparent in the infrared.

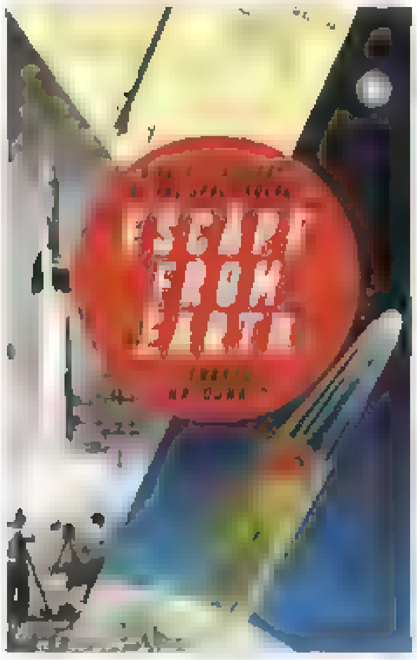
What do you think have been Spitzer's highlights?

First would be the identification of seven Earth sized exoplanets at least several of which are potentially habitable orbiting the same star some 40 lightyears from Earth. This is one example of our work on exoplanets, which has certainly been a high point of the mission. Another area of major impact has been our study of the earliest, most distant galaxies. Working in tandem with the Hubble Space Telescope, we have identified galaxies that are seen as they were when the Universe was no more than a few per cent of its current age and size. One off results, such as the spectrum of the interior material of Comet Tempel 1 as revealed by the Deep Impact mission, or the discovery of C60 (interstellar buckyballs) in space have been very exciting as well.

***Michael Werner** is a senior research scientist at the NASA Jet Propulsion Laboratory, California Institute of Technology. He has been the lead scientist for the Spitzer Space Telescope since 1984.*

GRIPPING READ

Escape From Earth



Fraser MacDonald
Profile Books
£20 ● HB

From University of Edinburgh historical geographer Fraser MacDonald, *Escape from Earth: A Secret History of the Space Rocket* is not what you might expect. It could be presumed that the large amount of material on rocketry in the early 20th-century does not need an addition, but with the page-turning drama as intense as any spy thriller, MacDonald touches on some of the most recognisable pioneers – from von Kármán to Oppenheimer – and settles on a man whose name is so unfamiliar that I had to look him up on Wikipedia.

Described by MacDonald as a radical, a socialist, a communist and an anti-fascist, Frank Malina was a US mechanical engineer of Czech ancestry. He surrounded himself with colourful personalities in 1930s Los Angeles, including the chemist and occultist Jack Parsons, to develop the world's first high-altitude sounding rocket. Their determination carried them from the California Institute of Technology campus to remote Arroyo Seco, where they earned the nickname 'Suicide Squad' for their dangerous experiments. Laying the foundations for the Jet Propulsion Laboratory, of which Malina later served as director, their legacy was America's first sounding rocket, the WAC Corporal, which reached the edge of space in May 1946.

MacDonald's story reveals a man, with a scientific mind and communist sympathies, who was quite incongruous and ill-fitting at a time when global geopolitics and the uneasy relationship between East and West meant rocket technology was seen as little more than a tool for war. ★★★★★

***Ben Evans** is the author of books on human spaceflight and is a science and astronomy writer*

Dante and the Early Astronomer

Tracy Daugherty
Yale University Press
£20 ● HB

The 19th-century astronomer Mary Evershed (née Orr) lived most of her life in India. She was fascinated by the Sun and the stars, but more unusually she was also fascinated by the 14th-century Italian poet Dante. This book looks into Mary Evershed's work on the medieval writer within the context of her life, introducing astronomers to Dante's work and Dante scholars to astronomy. We are presented with Evershed's life in chronological order, from her childhood through to her growing interest in Dante and astronomy, and on to eclipse expeditions, meeting and working with her future husband, following her husband to India and publishing her work on the astronomy within the poet's great work, the *Divine Comedy*. Throughout the book we are also told the story of Dante, with examples of where astronomy featured in his oeuvre and how this compares to astronomical thinking, then and now.

This is a story well worth telling. I was especially intrigued at the parallels between Mary and John Evershed and their friends Walter and Annie Maunder. As someone with little prior knowledge of Dante, I also found the explanations of his thought and life interesting.

More problematically, I found that for a book about a 19th-century female astronomer, who wrote and published throughout her life, there was very little of her own voice in this book. We are told how she must have thought and felt but given no evidence for it.

Overall, while Tracy Daugherty's book tells an interesting story, it would have been beneficial to have heard more from Mary Evershed herself. ★★★

***Emily Winterburn** is the author of The Stargazer's Guide: How to Read our Night Sky*

When We Walked On The Moon

David Long & Sam Kalda
Wide Eyes Publishing
£12.99 ● HB

When We Walked on the Moon is a timely publication, coinciding with the 50th anniversary of the lunar landing. It is aimed at a younger audience but amateurs of all ages will enjoy this book. David Long starts off with a brief history of the Space Race and Saturn V before launching straight into short chapters about the seven manned Apollo missions.

Long covers topics such as what living within the cramped capsules was like the engineering behind each mission and each voyage's purpose. Younger readers will enjoy learning about the experiments carried out, such as the 'Moon trees' planted in America from seeds flown on the Apollo 14 mission or the five mice taken on Apollo 17.

Psychology is covered too and it's a bit of a rollercoaster, describing the astronaut's thoughts and feelings from happiness to despair in a way that will strike a chord in us all. Using quotes from the astronauts throughout, often coupled with dark coloured illustrations, Long almost paints a bleak and lonely yet thought-provoking picture of going to the Moon.

The book concludes with brief accounts of the life of each astronaut. It is a nice touch but a glaring error regarding Michael Collins's 'two moonwalks' will perplex all Apollo fans. Despite this faux-pas, *When We Walked on the Moon* should not be cast aside. It is a good introduction to the Apollo missions that is charmingly illustrated by Sam Kalda and gives a sweeping account of the achievements by NASA during one of the most important eras in space history. ★★★

***Katrin Raynor Evans** is an amateur astronomer, a fellow of the Royal Astronomical Society and the librarian for Cardiff Astronomical Society*

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR

1 Apollo 11 Moon lander

Price £84.99 • **Supplier** Lego
Tel 0800 5346 5555 • **https://shop.lego.com**

Recreate Armstrong and Aldrin's legendary moonwalk using Lego's new Apollo 11 lunar lander set. The 1,087-piece set features a detailed replica of the Eagle lander on the Moon's surface, complete with mini-footprints and US flag.

2 IDAS nebula filter

Price £259 • **Supplier** Astroshop.eu
Tel +44 (0)203 868 8042 • **www.astroshop.eu**

Create crisp images and boost your visual observing of nebula with this filter. It lets through H-alpha H-beta, OIII and SII spectral lines, while cutting off the infrared, making it ideal for viewing and photographing foggy areas.

3 ATIKbase

Price £249 • **Supplier** Widescreen Centre
Tel 01353 776199 • **www.widescreen-centre.co.uk**

Streamline your imaging setup and increase its portability with the ATIKbase. The device is a small computer that allows you to control your cameras and other hardware using a single interface. It runs directly from a 12V power source.

4 Moon Trumps

Price £7 • **Supplier** Open University
Tel 01908 652026 • **www.oustudentsshop.com**

Which of our Solar System's moons is the biggest? Takes the longest time to orbit? Has the highest potential for life? Find out by using these cards to pit 36 moons against each other in a game of top trumps.

5 Universal saddle plate

Price €142.62 • **Supplier** Geoptik
Tel +39 045 925 0989 • **www.geoptik.com**

Increase your setup's adaptability with this universal saddle plate. The plate works with both Vixen- and Losmandy-style dovetail bars, meaning you can change equipment without changing the plate.

6 Warmawear heated glove liners

Price £15.99 • **Supplier** Primrose
Tel 0118 903 5210 • **www.primrose.co.uk**

Keep warm with these glove liners which have battery powered heating elements extending along each finger. Conductive patches on the finger tips mean you'll be able to use your touch screen devices without taking off your gloves.

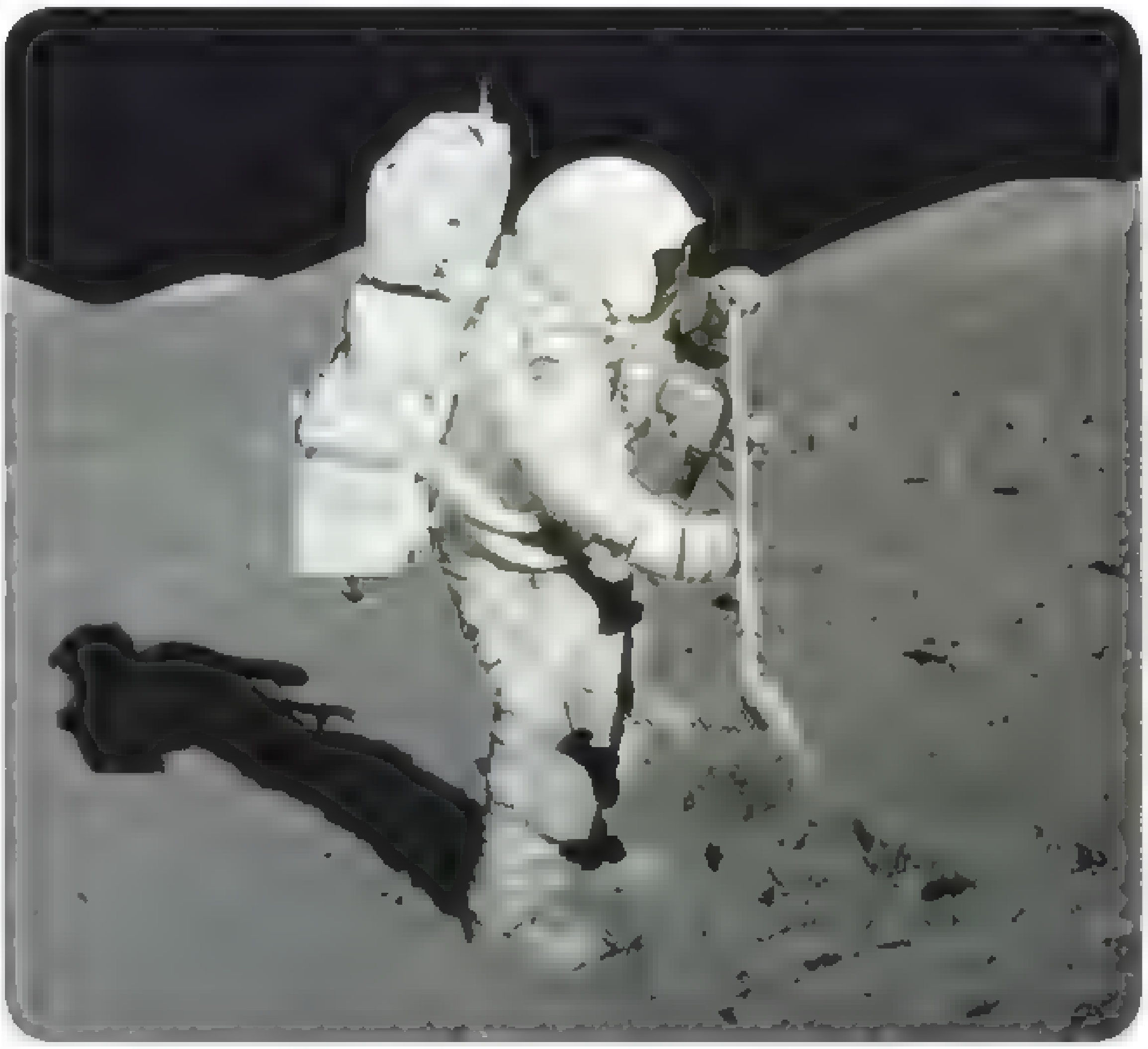

fisher space pen
The goes anywhere, writes everywhere pen
Guaranteed for life!
OUR PENS DON'T FAIL
ASK ANY ASTRONAUT
The AG7 pen as used by Neil Armstrong
on the first Moon landing, 20th July 1969
UK and European distributors:
GBA Pen Company Ltd.
Tel: 01245 225857
info@gbapen.co.uk
www.fisherspacepen.co.uk
fisher
SPACE PEN

Elizabeth Pearson interviews Jessica Barnes

Q&A THE LUNAR GEOLOGIST

To coincide with the anniversary of Apollo 11, NASA is releasing a collection of Moon rocks which have remained in storage for 50 years

What is so special about these Moon rocks?
The sample is a basalt – the rock that forms when volcanic lava solidifies. But the neat thing about the specific sample that we've been allocated is that it's been stored for almost 50 years at –20°C. It was collected along with three others from the same boulder that haven't been frozen for 50 years. It makes a natural comparison to look at the one that's been frozen versus the few that haven't been.



▲ Harrison Schmitt of Apollo 17 collects rock samples in the lunar rake. The stored anniversary samples come from Apollo 15, 16 and 17

NASA

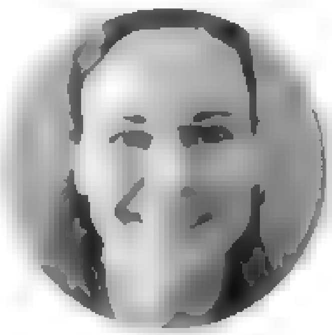
How were the two types of sample treated differently?
If we start with the samples which weren't frozen, they were returned to Earth by the Apollo astronauts, and were kept in a nitrogen cabinet – to prevent air from reaching the rocks – but at an ambient temperature of about 20°C. The frozen sample, however, was frozen within a month of being brought back to Earth. It was initially studied very briefly, but for the majority of its time on Earth it's been frozen.

Why were they frozen?
In the 1970s, NASA had the foresight to not make all the samples available right away. They preserved some of the rocks under different conditions so that future generations, with better technology and different questions, would be able to find answers using samples no one else has had access to.

What are you looking for?
We want to look at the water content which occurs in trace amounts in different minerals in each rock, to gain an idea of the lunar inventory of water and other volatiles. Hopefully, we can compare the water content between the frozen and non-frozen samples to see how the different curation techniques NASA employed for the Apollo samples worked, and how they've been affected by terrestrial contamination. Lastly, we'll look at the evolution of water and other volatiles from the time this rock was a magma, to when it solidified to when it was collected on the lunar surface.

How are you examining the samples?
We typically remove tiny fractions of the material, but generally the material is not destroyed, which means the samples can be used later. We will also measure the isotopic ratio. As different Solar System objects have different isotopic signatures, we can compare the samples to those we have from Earth or asteroids, building up a picture of how water arrived on the Moon, and how it evolved there over time. One member of our group will be measuring the ages of the different samples that we have to answer a question we don't know the answer to yet – did all these samples come from the same lava flow?

When we return to the Moon, what would we do differently now?
One of the things we hope to learn from this is how to curate future lunar samples, particularly volatile-rich material which may come back from the lunar poles. We're going to look at how different curation practices have influenced volatiles in the samples. Hopefully, we're going to inform best practices for curation and say the way that these samples have been stored hasn't affected them. Or we'll find that it has changed them, and that volatile-rich samples need to be kept frozen in future.



Jessica Barnes is an assistant professor in planetary sciences at the University of Arizona, focusing on investigating how the Moon formed and evolved.

How does it feel to be involved with the project?
These samples haven't been opened in 50 years. We're going to be the first people to look at them and study them. We need to create a catalogue of what these samples are like and what these general characteristics are, so that other people can request that information when they study them. For me that's a huge honour because I wasn't born in the Apollo era and now I get to be a part of that legacy, which is just fantastic.

Telescope House
Telescope Specialists Since 1785
Web: www.telescopehouse.com
Email: sales@telescopehouse.com
Tel: 01342 837098
Sign Up
Introducing the Explore Scientific iEXOS-100 PMC-Eight Mount: an innovative, highly portable German Equatorial mount. Built for both visual astronomers and astrophotographers alike, this mount will take a visual payload of 19lbs/8.6kg, or a more modest imaging payload of 15lbs/6.8kgs - held in place by a standard Vixen-profile saddle plate. This mount makes an ideal pairing with the Explore Scientific 80 and 102mm Apo Triplet refractors.
Controlled by the class-leading PMC-Eight wireless control system, this mount doesn't require a handset and will run off any modern Android device, Apple iPads (running iOS12+), or Windows 10 tablets and computers. In addition to these packages, the PMC-8 is also fully ASCOM compliant and will connect to any ASCOM Standards Compliant POTH Client from Explore Scientific (either wired or wireless) to work with virtually any sky software that supports ASCOM. The Explore Stars control app can be downloaded from Android, Apple and Windows app stores and is a very intuitive piece of software, with the ability to use your device's GPS signal to download location and time & date data - no more entering info by hand. Explore Stars allows for simple setup with the click of a button. The PMC-Eight hardware is based around 8 separate CPUs - neatly apportioning different control instructions and calculations to each processor. Tracking and slewing is quiet and the mount also comes with an ST-4 Guide port for autoguiding. Looking for a super-portable, visual and astrophotographic mount? You've found it...
NEW Explore Scientific iEXOS-100 Mount
PMC EIGHT
PRECISION MOTION CONTROLLER
Explore Scientifc 127mm FCD100 Carbon Fibre Apo - £2287
EXPLORE SCIENTIFIC
165mm & 152mm + Losmandy G11 PMC8 Mount Megadeals
Telescope House are pleased to bring you these two unique deals buy the extraordinary Explore Scientific 165mm or 152mm Apo Triplets together with the advanced Explore Scientific Losmandy G11 PMC8 Wireless Control Mount and make massive savings.
Explore Scientifc Maksutov Newtonian - £892
TeleVue
Browse the complete TeleVue eyepiece range on our website
Get organised with the Explore Scientifc Eyepiece & Accessory Bag- £25
NEW!
Introducing the Explore Scientifc 52-Degree Eyepiece Waterproof LER range From £59.99
NEW!
Bresser Astrophoto Tracking Mount From £265
NEW!
The Bresser Astrophoto Tracking Mount is designed to be used with DSLRs and small telescopes for long duration astrophotography, providing a tracking platform to counteract the Earth's rotation and create wonderful wide field shots of the skies above us.
Available in head only and wedge tripod configurations.
Explore Scientific Sun Catcher Solar Filters From £18
Lunt LS50 - From £1183
Excellent pressure-tuned portable Solar Scope
Explore Scientific Solarix Solar Film Filter £18
Lunt LS60 - From £1880
Excellent Value 100% Safe Solar Film. Ideal for DIY!
Lunt LS80/B1800 - £5214
Find the full range of ZWO Cameras at Telescope House From £151
Bresser Full HD USB Camera/ Eyepiece £50
Lunt LS100/ B1200 - £6478
ZWO ASIAIR Wireless Scope control, Autoguiding & more From £179
Website: www.telescopehouse.com
Email: sales@telescopehouse.com | For sales and advice call: 01342 837098
All prices correct at time of press. Subject to change. Errors and omissions excepted.

THE SOUTHERN HEMISPHERE

With Glenn Dawes

Look for Milky Way constellations and see the mid-month occultation of Saturn by the Moon

When to use this chart

1 Aug at 24:00 AEDT (13.00 UT)
15 Aug at 23:00 AEDT (12.00 UT)
31 Aug at 22:00 AEDT (11.00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

AUGUST HIGHLIGHTS

On 12 August, Saturn is occulted by the Moon for the second time this year. The event is best suited for mid-latitude eastern Australia. It disappears behind the dark lunar limb from Brisbane and Sydney at 18:15 and 18:34 respectively. Although shortly before the end of twilight sky glow shouldn't interfere. From northern Australia the occultation is a daylight event with Tasmania, Southern Victoria and South Australia seeing a near miss.

STARS AND CONSTELLATIONS

Long August evenings present a view of the Milky Way from the Southern Hemisphere. Commencing at the end of twilight, deep in the southwest lies the asterisms of the False Cross with Crux and its pointer stars above. Directly overhead is the teapot of Sagittarius. Following this white river northward finds the upright but inverted crucifix of Cygnus the Swan near the northern horizon. By midnight more northerly aspects such as Lacerta may be visible depending on your latitude.

THE PLANETS

The evening sky is the realm of the gas giants with Jupiter (near Antares) transiting or due north around 20:00 mid month. It is followed by Saturn, near the teapot of Sagittarius, about two hours later. The attractions of the morning sky remain in the outer Solar System. Neptune, which had arrived early in the evening, is due north around 02:00 with Uranus following just before dawn. Mercury is only visible in the eastern dawn glow for the first half of August.

DEEP-SKY OBJECTS

The small constellation of Scutum the Shield, may be obscure but being in the Milky Way it's rich in deep sky objects. From mag. +3.8 Alpha Scuti move 2° east-southeast and discover the triple star Delta Scuti (RA 18h 42.2m, dec –9° 03'). Its mag. +4.7 primary is a famous variable star, however visually, it's better known for its yellow colour contrasting with the blue of its brightest (mag. +9.2) companion.

Continue to the east-southeast a further 0.8° to the open cluster NGC 6694 or M26 (RA 18h 45.2m, dec –9° 23'). Although being eighth magnitude it's spread over approximately 15 arcminutes, with small scopes showing a few brighter stars in a faint haze. Larger apertures reveal a rich field of faint (12th to 14th magnitude) stars, merging into the stellar background of the Scutum star cloud.

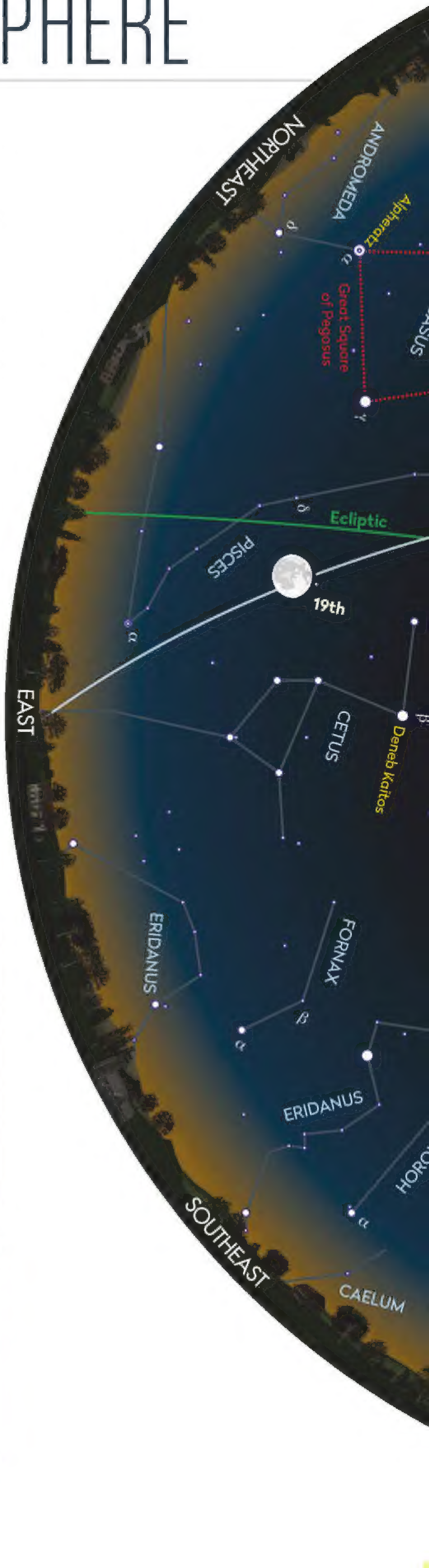
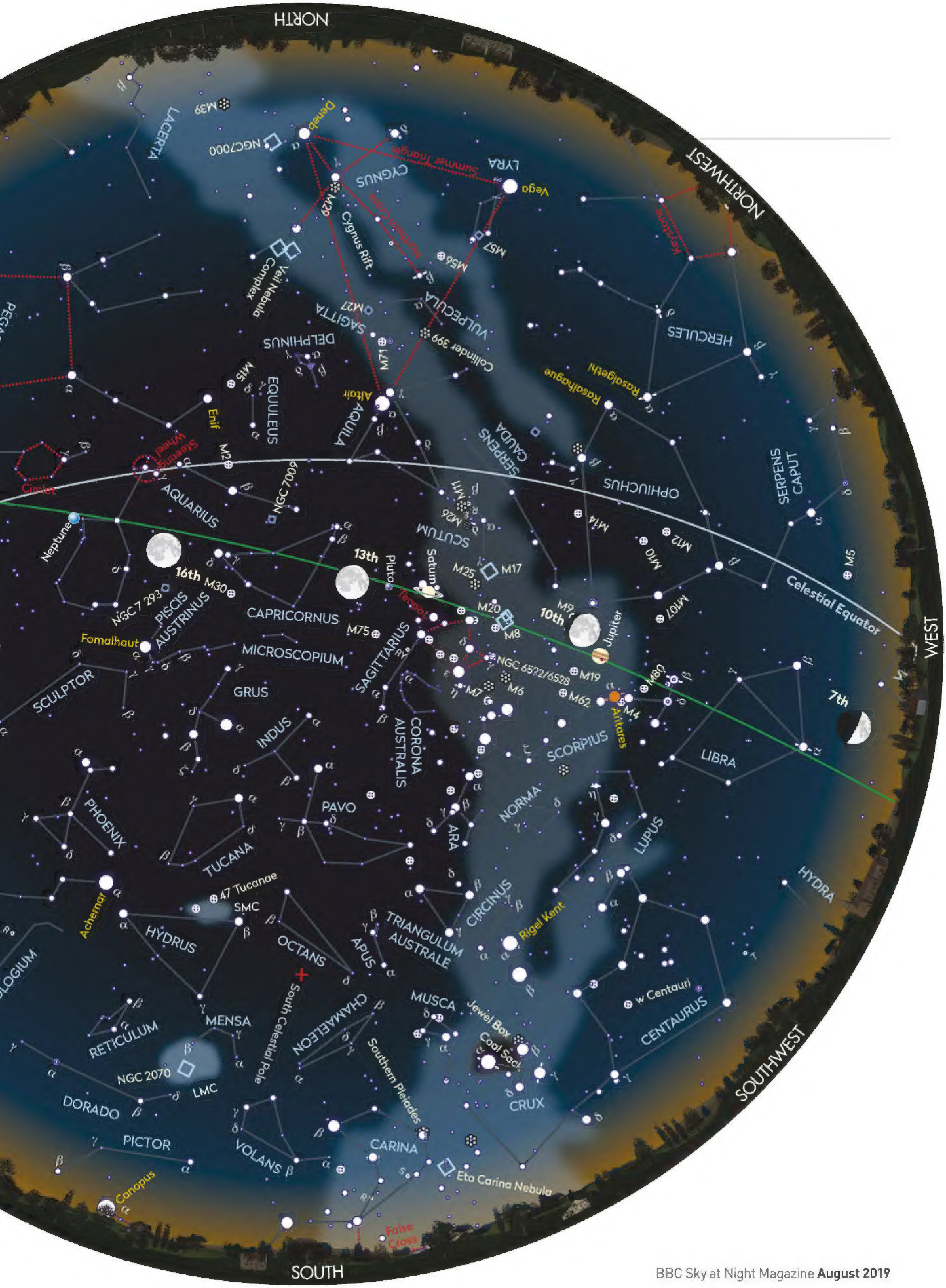


Chart key

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

CHART: PETE LAWRENCE



NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LACERTA
M39
Deneb
NGC7000
CYGNUS
Summer Triangle
LYRA
Vega
M29
Cygnus Rift
Northern Cross
M57
M56
Veil Nebula Complex
Keystone
HERCULES
SAGITTA
M27
VULPECULA
Collinder 399
DELPHINUS
M71
Rasalgethi
Rasalhague
Altair
AQUILA
EQUULEUS
M15
Enif
PEGASUS
Steering Wheel
Circlet
M2
NGC 7009
AQUARIUS
SERPENS CAUDA
OPHIUCHUS
SERPENS CAPUT
M11
M26
SCUTUM
M14
M10
M12
M5
Neptune
16th
13th
Pluto
Saturn
M25
M17
M30
NGC 7293
PISCIS AUSTRINUS
CAPRICORNUS
Teapot
M20
M8
10th
M9
Jupiter
M107
Celestial Equator
Fomalhaut
M75
SAGITTARIUS
MICROSCOPIUM
NGC 6522/6528
M19
M80
M7
M6
M62
M4
Antares
7th
SCULPTOR
GRUS
INDUS
CORONA AUSTRALIS
SCORPIUS
LIBRA
PHOENIX
PAVO
NORMA
ARA
LUPUS
TUCANA
HYDRA
47 Tucanae
SMC
Achernar
HYDRUS
CIRCINUS
TRIANGULUM AUSTRALE
Rigel Kent
OCTANS
APUS
HOROLOGIUM
South Celestial Pole
CHAMAELEON
MUSCA
Jewel Box
ω Centauri
CENTAURUS
MENSA
RETICULUM
Coal Sack
NGC 2070
LMC
CRUX
DORADO
Southern Pleiades
PICTOR
VOLANS
CARINA
Eta Carina Nebula
Canopus
False Cross